JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA
FOR THE PROMOTION OF THE MECHANIC ARTS

VOL. CLXIV, NO. 3 82ND YEAR SEPT., 1907

The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal.*

THE FRANKLIN INSTITUTE.

Southern Appalachian Streams.*

BY CHARLES E. WADDELL,
Consulting Engineer, Biltmore, N. C.

As the streams of the Southern Appalachians are destined to play an important role in the industrial development of the South, I deem a consideration of their characteristics and salient features of sufficient interest to merit your attention to-night.

From the days of the Colonies until the time of the Civil War the South was essentially an agricultural community and little or no manufacturing was done. Events subsequent to the Civil War have changed the conditions, and the South is becoming not only the leading producer in the three great crops of cotton, rice, and tobacco, but it is forging ahead along industrial lines. Not very long ago cotton was exported from the fields of Alabama and Georgia to the factories of New England. It is now generally recognized that the better practice is to finish the raw product where it is produced, hence the

*A lecture delivered before Franklin Institute, in the Hall of the Young Men's Christian Association, October 22d, 1906.

factories have moved to the cotton fields. One of the most potent influences in the creation of the industrial South has been the perfecting of methods of transmitting electrical power long distances, and the generation of this power from the numerous rivers. The pioneer work in this line was done at Anderson and Pelzer, South Carolina, about 1895; I believe that it was in these two places that hydro-electric plants were first used to drive cotton mills. The experiment was watched with deep interest, and the results achieved were a stimulus to general development and application.

To arrive at a clearer understanding of the prominent features of the streams under discussion, it is first necessary to consider the physiography of the region. The Atlantic seaboard in the Southern States presents three types of formation. First, the Coastal plain; further inland, the Alluvial belt, and still further the Appalachian range of mountains, and while this chain extends from Maine to Alabama, and is variously known as the White Mountains, the Adirondacks, the Alleghenies, and the Blue Ridge, it is with the Blue Ridge that we are concerned this evening.

To the south of the Shenandoah Valley, in Virginia, occupying portions of Virginia, North Carolina, South Carolina, Georgia, Tennessee, and Kentucky, lies a tableland more than three thousand feet above the sea level, seventy miles wide, and three hundred miles long, known as the Southern Appalachian plateau. All of the important streams south of the Ohio River, in the Mississippi, Gulf, and South Atlantic drainage, trace their source to this plateau. The physical feature that differentiates the Southern Appalachians from the rest of the system is the way the rivers rise. Northern rivers, such as the James and Susquehanna, rise on the most westerly ridge and break through the intervening ranges, wending their way to the ocean. The New River, rising on the slopes of Grandfather Mountain, in North Carolina, in the most easterly range, and flowing into the Ohio, is the first stream to violate this law, and establishes a precedent followed by all other Southern rivers, hence we find all streams flowing north, south, east and west rising on the slopes of the Blue Ridge.

The plateau is bounded on the east by the Blue Ridge and on the west by the Unaka range. The eastern slopes of the

Blue Ridge are gradual and form the Piedmont section, noted for its richness and agricultural value. The Unaka mountains, on the other hand, are higher, more rugged, and cut by the rivers into innumerable gorges. Lying between the two ranges are sundry irregular cross ridges, called the "Blacks," "Craggies," "Balsams," "Cowees," "Nantahalas," and "Smokies." Contained in these groups are 275 peaks over five thousand feet high, and thirty-six exceeding six thousand. Conspicuous among the last is Mount Mitchell, the highest peak east of the Mississippi, and the oldest land on the American continent. The mountains are clothed to their summits with forests of the finest hardwoods. The flora is of the richest and most beautiful, due no doubt to the copious rainfall.

The rainfall over the whole area averages fifty or more inches per annum, and in the vicinity of Highlands, N. C., reaches the extreme figure of seventy inches. With the exception of Puget Sound, this is the greatest precipitation in the United States.

This tract, embracing approximately 10,000 square miles, is the natural reservoir that supplies, replenishes, conserves, and tends to make uniform the flow of all the rivers.

Uniformity of flow depends largely on the nature of the soil, the character and extent of the country drained, the presence or absence of lakes, and the distribution of rainfall. In the South lakes and glacial deposits are entirely lacking, hence the streams depend solely on the rainfall. Fortunately this is greatest in summer and least in winter, for in summer the requirements of plant life and the increased evaporation demand more water than the other seasons.

The rivers emanating from this plateau in the course of their length present three distinct types. First, in the mountains they descend rapidly, are confined in narrow channels, and abound in falls and cascades, along which portion they are susceptible of hydraulic development in innumerable places; their value for power purposes is, however, curtailed by the limited drainage area. The second stage is through the Piedmont section, where the streams contain their finest water power and are themselves of great magnitude, for miles descend shoal after shoal. This is the portion usually designated as the "Fall Line." The final stage is below the Fall Line, where

they lose their dynamic force and become navigable bodies of water.

The pre-eminent apex of the drainage area in the Southern Appalachian Plateau is Grandfather Mountain, in North Carolina. It is the highest peak in the Blue Ridge, and to its slopes four great rivers—the New, Yadkin, Catawba, and Holston,—trace their source. The New River, to which allusion was previously made, rises on the northerly slopes, crosses the State of Virginia, and after its confluence with the Gauley, is known in West Virginia as the Kanawha. Its head waters comprise the counties of Ashe, Wautauga, and Allegheny in North Carolina. Its valley in the State of Virginia is famed for its beauty, and although the river possesses great fall, and its characteristics are well known, yet it is one of the least developed of the Southern streams. The proximity of the Virginia coal fields is doubtless accountable for this condition.

Considering the water courses in rotation, the next claiming attention is the Roanoke. This river is formed by the Dan and the Staunton at Clarkesville, Virginia, and while not strictly speaking a Southern Appalachian stream, it may be so classed, for although the Staunton does not drain the Southern Appalachian Mountains, the Roanake's course lies wholly in the territory so drained. Neither the Staunton nor the Dan have any marked fall. The Roanoke crosses the fall line at Weldon, North Carolina, draining at this point more than 9,000 square miles, and the fall in nine miles exceeds eighty-five feet. If properly supplemented with steam 75,000 horse power could be generated in this locality, although its value for power purposes is limited to a marked degree by the violent floods and extreme fluctuations to which it is subject. The flood flow is often sixty-one times the minimum, an unusual condition in a stream with so large a drainage area. The Roanoke Rapids Power Company have developed the river to some extent, and are furnishing power to a number of industries in the town of Roanoke Rapids.

The Cape Fear, the river next in succession, claims the distinction of being the only large river, together with its tributaries, that lies wholly in one State. Formed at Moncure by the junction of the Deep and Haw Rivers, the Cape Fear crosses the State in a southeasterly course and empties into the At-

lantic at Southport, a town thirty miles below Wilmington. This river gets its name from the noted Cape Fear, a point dreaded by mariners almost as much as Cape Hatteras. With the exception of the Susquehanna, this stream is subject to greater floods and lower stages than any other stream on the Atlantic seaboard. The river is navigable as far up as Fayetteville, and previous to the general extension of the railroads attempts were made to increase this distance. A few miles above the town the fall line is encountered, and for thirty miles the river descends a succession of shoals.

The river is developed at a number of points, the power in every instance being used to drive mills in the vicinity. There is, however, an hydro-electric plant of some magnitude being constructed at Buckhorn Falls, the history of which is of interest. In 1796, the State granted a charter to the Cape Fear Navigation Company to erect dams, build locks, and render the river navigable in this locality. $80,000 or $100,000 were spent and practically nothing accomplished. The work was continued at intervals, and after passing through countless vicissitudes, and spending $350,000, the project of navigation above Fayetteville was abandoned at the beginning of the Civil War. In part by natural causes, and in part intentionally, the works were destroyed. In 1868, the State appropriated the property to the Raleigh and Augusta Railroad Company. A little later it was bought by the Deep River Manufacturing Company, an interest largely controlled by the Lobdell Car Wheel Company of Wilmington. Delaware, who owned iron mines in the vicinity and were seeking water transportation. Between 1876 and 1880 boats were run occasionally, and since 1880 have ceased altogether. The difficulty throughout has been in getting the ends of the dams and the locks protected from freshets. The present owners, with the intention of developing electric power for transmission to Raleigh and Fayetteville, acquired the property in 1895. Lawsuits contesting the riparian rights, together with other unfortunate circumstances, have resulted in the complete tie-up of the property.

The Yadkin and Catawba, two rivers of prime importance, are next in order. A peculiar feature of these streams, and one common to numerous others, is that where they leave a

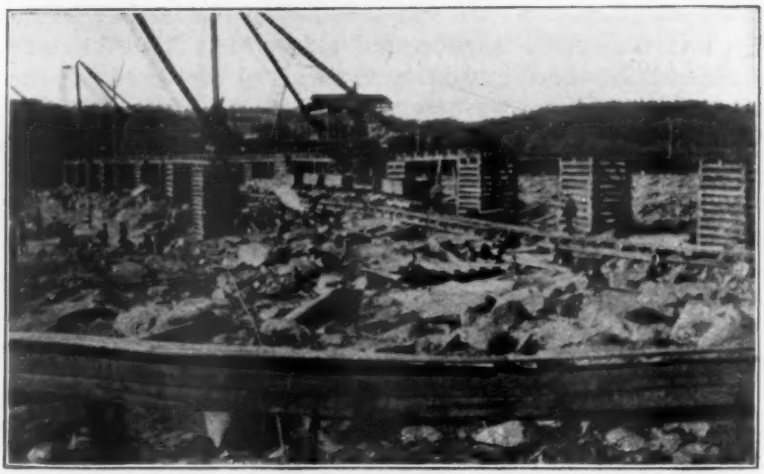


Fig. 1. Views of the Yadkin at the Whitney Reduction Company's plant: 1st, The Yadkin. 2d, The Bed after Diversion. 3d, Dam in Process of Construction.

State, they change their names, thus the Yadkin and Catawba of North Carolina become in South Carolina the Great Pee Dee and the Wateree.

The Yadkin rises on the southern slopes of Grandfather Mountain, is in all some four hundred miles long and empties into the Atlantic at Georgetown, South Carolina. The fall line is crossed at Cheraw, about 150 miles from its mouth, above which point falls and shoals abound, the most prominent being Bluitt's Falls and the Famous Narrows. Both are being developed at present, the former by the North Carolina banking house of Hugh McRae & Company, who expect to secure about 15,000 horse power, and transmit to the milling town of Darlington; and the Narrows by the Whitney Reduction Company, a Pittsburg corporation. Probably the most striking hydrographic feature on any Southern stream is the Yadkin Narrows, the great river draining more than four thousand square miles of territory, and which in the vicinity of Salisbury, North Carolina, is nearly half a mile wide, at a point about twelve miles southeast of the town contracts to a width of one hundred feet, in places even narrowing to sixty feet, and for four miles roars and crashes in a gorge that it has worn down through the solid granite. The development contemplated consists of a dam some fifty feet high at the head of the rapids and a canal several miles long. Forty thousand horse power will be generated and will be transmitted at a potential of sixty thousand volts to the adjacent manufacturing towns.

Like Yadkin, the Catawba rises on the Blue Ridge, one of its principal tributaries, the Linville, traces its source to the southwestern slopes of Grandfather Mountain. The Catawba crosses the State line twenty miles south of Charlotte, below Columbia, together with the Congaree, it forms the Santee and empties into the ocean in the vicinity of Georgetown. The fall line is crossed at Camden, above which point an area of five thousand square miles is drained. From Camden to the foot of the mountains sixteen notable shoals are encountered. On ten of these developments are being projected at the present moment. The first hydro-electric plant built on this river was the Catawba Power Company's 10,000 horse power plant at Rock Hill, South Carolina. This property, with others, has been merged into a corporation known as the Southern Power

Fig. 2. Dam and canal of Southern Power Company's Great Falls plant, 30,000 horse power, Catawba river.

Company. With a paid-up capital of $10,000,000, the Southern Power Company enjoys the two-fold distinction of being one of the largest power companies in the country and of being built with Southern capital. An ultimate development of ten plants with an aggregate capacity of 132,000 horse power is planned. Of this amount 122,000 horse power will be obtained from the Catawba River alone. The fact that there is a market for so great an amount of power impresses an observer with the titanic proportions of the New Industrial South, and when it is realized that this is but one company and one river the scope of the entire possibilities is not easily grasped. The Piedmont section is the manufacturing district of the Carolinas, and it is the heart of this territory that is controlled by the hydro-electric plants of the Catawba and the Yadkin. In a radius of fifty miles of Charlotte a conservative estimate of the hydraulic developments contemplated or in process of construction would be a total capacity of not less than 250,000 horse power. The amount and price of the power, the railroad facilities, the character of the population, and the salubrity of the climate are fast making this particular section the great manufacturing center of the South, and a district which in time will rival Lowell, Holyoke and other New England centers, even as Birmingham is now rivaling Pittsburg in the iron market.

The limited time precludes consideration of all of the streams, and although the majority possess enormous undeveloped power, and many are developed to some extent, a discusion of the Broad, Toxaway, Saluda, Savannah, and others must be omitted, and your attention next directed to the Chattahoochee, conspicuous in this instance as it is the first of the Southern Appalachian streams to reach the Gulf. Rising in North Georgia, the river for the greater portion of its length forms the boundary line between Georgia and Alabama. The Atlanta Water Power Company's Morgan Falls plant, distant some thirty miles from Atlanta, is at present the largest development on the river, and furnishes the greater part of the power used in the City of Atlanta. The North Georgia Electric Company, at a cost of upwards of $7,500,000, propose to develop other powers on this river and also on its tributary, the Chestatee, and it is credibly reported that an immense de-

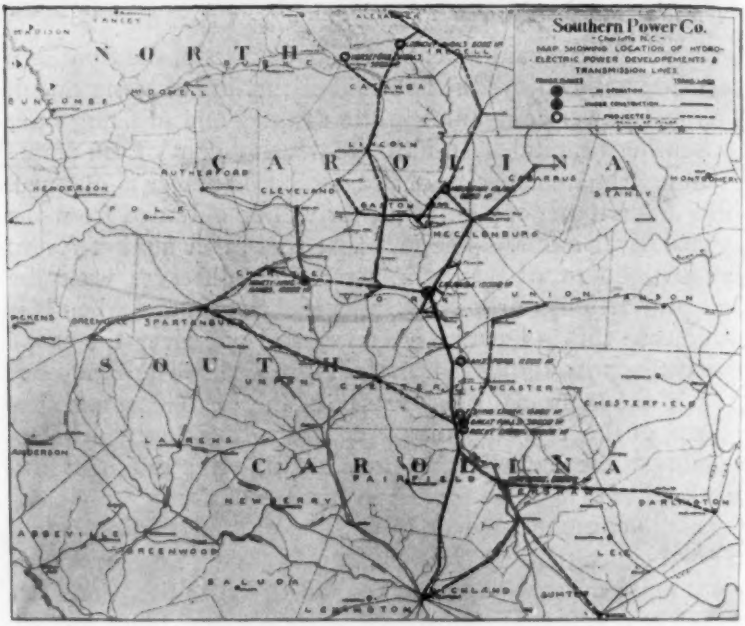


Fig. 3. Map of Southern Power Company's hydro electric plant and transmission lines.

Fig. 4. Atlanta Water Power Company's Morgan Falls plant, Chattahoochee river, 10,500 kilowatts 48-foot head, 20,000 volt, 30-mile transmission.

velopment is shortly to be made at Columbus, Georgia, where one large plant now exists.

Passing to the western drainage system, the first prominent stream to claim attention is the Little Tennessee. Rising in Rabun Gap, in Georgia, it crosses Western North Carolina and cuts its way through the Smoky Mountains. A characteristic of all Western rivers is the deep canyons they have cut through the Unaka range. In some past age the hills have been rent asunder, and the streams have slowly but continuously worn away the stone cliffs. At the North Carolina-Tennessee State line the Little Tennessee drains an area of two thousand square miles and for a distance of four miles in North Carolina is a roaring torrent falling a total of 240 feet The river is comparable here with the Narrows of the Yadkin, and inferior only on account of the lesser drainage area and consequently the lesser amount of water. A development to the extent of 50,000 horse power is planned in North Carolina, which, taken with a projected development of 20,000 horse power a few miles across the State line, makes the river one of the most noteworthy power streams in the Western system.

Second in importance to the Little Tennessee is the French Broad. This stream rises in the Pisgah Forest, of the Biltmore Estate, and by reason of the protection the forests afford is freer from excessive floods and low minimum stages than any other stream. From Brevard to Asheville the fall is slight. A few miles north of the city the rapids begin and in a distance of forty miles the fall is seven hundred feet, while the area drained is about eighteen hundred square miles. Its value as a power stream is curtailed by the proximity of the railroad, which precludes the construction of high dams and limits developments to small units.

At this time there are but two hydro-electric plants in operation on the western rivers, one of these located at Asheville, on the French Broad, the other near Waynesville, on the Pigeon River.

A large hydro-electric plant is now under construction at Hale's Bar, on the Tennessee River, forty miles below the City of Chattanooga. The Tennessee River is formed a few miles from Knoxville, Tennessee, by the confluence of the French Broad and the Holston; at Chattanooga it counts as its tribu-

Fig. 5. Weaver Power Company's dam, French Broad river.

Fig. 6. Interior Weaver Power Company's plant, French Broad river.

taries the Holston, the Wautauga, the French Broad, the Big and Little Pigeon, the Little Tennessee, the Hiwassee, and a number of other smaller streams, including in fact the whole western drainage. Normally the river is navigable as far as Knoxville, although below Chattanooga pronounced shoals exist which interfere with navigation in certain seasons. The United States Engineers after years of study reported the most feasible method of improving the river would be the construction of a dam at Hale's Bar sufficiently high to back water to Chattanooga. Congress sanctioned the plan, and granted permission to individuals in Chattanooga to cöoperate with the Government and to utilize the power so obtained for commercial purposes. It is anticipated that 50,000 horse power will be available, and the undertaking is a striking illustration of the excellent results that can be accomplished in improving our water ways where local interests and the Government work harmoniously.

This brief discussion would not be complete with a consideration of methods that will insure the future usefulness, and policies that will improve the streams of the Southern Appalachian plateau. Since nature has denied lakes it will be necessary to create artificial bodies of water. Lake Toxaway and Fairfield are examples of what may be accomplished at a reasonable cost, while primarily intended for pleasure resorts and to enhance the beauties of the Sapphire country they have incidentally proved to be most valuable in regulating the flow of the streams on which they are located. In the case of Lake Toxaway one inch of rainfall over its entire watershed will raise the level of the lake but ten inches, granting that all of the precipitation could immediately reach the lake, while with the confined limits of the overflow weir thirty or more days would be required to discharge this quantity of water.

Nature was lavish in her provisions of forests, but these are now being rapidly demolished, a fact that should be a matter of national regret. That the forests wield a potent influence on the flow of streams can be stated without fear of contradiction. Floods and low water seasons have always existed, and probably ever will, but it has been demonstrated beyond reasonable doubt that on streams where the head waters are protected by plant growth these conditions are reduced to a minimum.

The forests exert a fourfold influence on the streams; by the mechanical action of the trunks, limbs, and leaves, they break the fall of the raindrops; the roots keep the ground open and porous, thereby assisting percolation; the forest floor, consisting of the humus and debris, is from its hygroscopic nature a most excellent filter and preventative agent to the formation of rivulets and gullies, forcing the water to soak in and seek subterranean drainage; the cooler atmosphere of the forests appre-

Fig. 7. Ruthless destruction of timber in Western North Carolina.

ciably retards evaporation. This, however, is to a large extent offset by the amount of water required for transpiration when the trees are in leaf.

Since wood is more widely used by man than any one other material it would be ridiculous to assert that the forests must be protected to the exclusion of the lumbering industry, but it is not unreasonable to demand that the present crude and extravagant methods be superseded by more enlightened practices.

A greater menace, and more destructive than the lumber-

men are the annual forest fires, which kill the seedlings and undergrowth, destroy the floor, and preclude the possibility of the forest reproducing itself. Generally the fires may be attributed to carelessness, and only in the rarest instances is malice the cause.

The small agriculturalist is almost as serious a factor as either the lumberman or the fires. The mountain sides by reason of their steepness are unsuited to agriculture, and are abandoned after a few crops as the fertile soil has been washed away and erosion ensued.

It is erroneous to suppose that a primeval forest of gigantic growth is essential to the preservation of a stream. Any growth that meets the four requirements previously mentioned and excludes agriculture is all sufficient. In my opinion a low copse growth is to be preferred. Ere long it will be necessary to replant many districts, and the cost and most suitable trees will be the subject of much discussion. At present afforestation is conducted on the Biltmore Estate at the small cost of $15 an acre. The plantings are usually white pines, and a growth of marketable timber is anticipated in about twenty-five years.

The measure to establish a Southern Appalachian Forest Reserve now before Congress is most commendable, and is probably the only solution of the problem of preserving the forests, and incidentally the streams, for the National Government rather than the State can exercise a more far-reaching control, replant denuded tracts, and organize a system of fire protection. The rivers being interstate waterways, their protection should from the nature of the case be a national matter.

In conclusion it may be stated that the streams issuing from the Southern Appalachians are capable of being developed to the extent of 1,000,000 horse power, while 200,000 horse power would be an extreme figure for the amount now in actual use, and were it possible to market the entire power an annual income of $30,000,000 would be derived. On the plateau there falls each year sufficient rain to make a lake four feet deep over the entire States of Rhode Island, Delaware, and New Jersey. To conserve this rainfall and to develop the enormous powers are the problems with which the South is now deeply concerned.

PHOSPHORUS FROM WAVELLITE DEPOSIT AT HOLLY SPRINGS, PA.

Until recently phosphorus, which is used chiefly in the manufacture of matches, was made solely from bones and organic substances. Only since the perfection of the electric furnace have natural phosphates been used to any extent in making phosphorus. The extraction of phosphorus from mineral deposits has been investigated by the United States Geological Survey, and the forthcoming number of the annual "Economic Bulletin" will contain an article by George W. Stose on phosphorus ore at Holly Springs, Penna.

At the foot of the northern slope of South Mountain, in the vicinity of Mount Holly Springs, about ten miles southwest of Harrisburg, a deposit of wavellite occurs in the white clay associated with manganese and iron ores. Small quantities of phosphorus had previously been obtained from phosphorite and from apatite, but wavellite, which is aluminum phosphate, has never before been used commercially in the manufacture of phosphorus, as the mineral generally occurs in very limited quantities.

The American Phosphorus Company was organized by Philadelphia capital to develop the deposit and a mill was built nearby. The mine was opened in 1900, the first years being devoted to prospecting and experimenting with the reduction of the ore. During 1905 the mine was in active operation and 400 tons of ore were reported to have been extracted and reduced in the company's furnaces.

The different methods of manufacturing phosphorus are described. The Readman process, patented in 1889, is the one that has come into commercial use in most countries.

The world's production of phosphorus has been variously estimated to be from 1000 to 3000 tons a year. The greater part is made in the Albright & Wilson factory, Wednesfield (Oldbury), England, where the Readman process originated. Other large factories are located at Lyons, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and there are numerous smaller ones in Russia.

The zinc smelters of Holland, Belgium, and the west of Germany receive their ore supplies through the ports of Hamburg, Rotterdam and Antwerp, but chiefly through Antwerp. These smelters have been for many years dependent upon foreign mines for nearly their entire supply of raw material. The system of receiving these supplies has therefore become well organized through long experience. This organization has made Antwerp the favorite port of entry. There are at that port convenient docks for unloading and trans-shipping the ores; agencies for the sampling of the ores as received; brokerage houses for the consummation of transactions in custom lots; and public assay offices for the determinative work that may be required. Antwerp is, moreover, conveniently situated with respect to the principal smelters of Holland, Belgium and the Rhine, has excellent railway connections, and also is the terminus of an extensive canal system, by which cheap transportation to the works can be secured.—*Eng. and Min. Jour.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, October 11, 1906.)

A Résumé of the Literature of the N Rays, the N_1 Rays, the Physiological Rays and the Heavy Emission, With a Bibliography.*

GEORGE FLOWERS STRADLING, PH.D.

(Concluded from vol. clxiv, p. 120.)

Let us return to the Comptes Rendus of Jan. 15, 1906. The second paper on the N rays is by Gutton.[109,110] Blondlot had found that when N rays fall upon the primary spark gap of a Hertzian oscillator the secondary spark becomes less bright. In the hands of Gutton this receives considerable development. He claims that the diminution of brightness of the secondary spark is very marked. Photography was used to obtain an impartial registration of this effect. The secondary spark illuminated a photographic plate for a minute, while the N rays fell on the primary spark. Another part of the plate was acted on by the spark when the N rays no longer reached the primary spark. After development the two images are found to be different. Precautions were taken to avoid any effect due to changes in the primary circuit or to unconscious bias in shifting the photographic plates. Every one of thirty-seven experiments showed a difference between the two images.

To this experiment the Revue Scientifique[216] objects that though the shifting of the plates was governed by a metronome, yet it was executed by hand and not mechanically. The secondary spark, less stable than the primary, accordingly evokes less confidence even than the primary spark did in Blondlot's photo-

*Numerals above the line refer to the numbers of papers in the bibliography at the end of this article.

graphic experiments. Besides, though all that Gutton claims be granted, no argument for the likeness of the cause of the effect to light waves can be drawn.

At the meeting of the French Physical Society on March 2, 1906, Cotton and Raveau[152] spoke upon Gutton's experiment. They went to Nancy to see the experiment and spent almost all of Feb. 24, 1906, in going over the experiment, using both the arrangement already published and also another not yet made public. At first they seemed to notice an effect of the N rays upon the secondary spark. When, however, they found that the removal of the source of N rays, a Nernst lamp, made no difference in the appearance of the spark, they were driven to hold that it must be the opaque screen, moved now into, now out of the supposed path of the N rays, which caused the effect. Cotton asked for a simple modification of the screen and was much surprised when both Gutton and Virtz opposed the change. When for the visiting physicists the experiments were performed in only partial darkness, in order to make sure that no wires belonging to the none too stable collection of apparatus moved when the screen was shifted, the results obtained were not so good as before. They further asked Gutton to let them have the photographic plates developed by some one who did not know what to expect. This Gutton did not grant. It is no wonder that the visitors took away with them no great reliance upon the decisiveness of the experiment.

Early in March Swinton[189] made public his lack of success in repeating Gutton's experiment. He inserted a Duddell thermogalvanometer in the secondary circuit but found no variation of energy to follow the application of the N rays to the primary spark.

Relying upon the promise of Blondlot and Gutton to demonstrate to him objectively the existence of the N rays, Guinchant,[159] like Cotton and Raveau, visited Nancy. In only three or four instances out of several hundreds did he observe a change of the secondary spark in Gutton's experiment with a change in the position of the intercepting screen. As he himself appeared unable to see the difference in the spark, he suggested that Gutton observe while he manipulated the opaque screen. Gutton declined saying that under the suggested conditions the eye of the observer would note no change.

Gutton saw changes in the spark at times when Guinchant saw no change. The latter says the spark varied periodically.

The possibility of a heavy emission from metals has been investigated by Gebhardt.[155] He placed a photographic plate above and one below a sheet of metal, all being in horizontal planes. The lower plate was more affected.

Let us now turn our attention to the various explanations which have been given for the rise and development of this series of rays, in whose existence scarcely any one outside of France at the present time believes. To any person who is inclined to feel a sense of superiority because the delusion was not cherished by any distinguished physicist of the English speaking world, a perusal of the series of papers on Hot Ice in Nature, vols. 22, 23, 24, is recommended as a corrective.

The discovery of the N rays was announced at the psychological moment for obtaining belief in them. The kathode rays, the canal rays, the X rays, the α, the β, the γ rays had accustomed the scientific mind to hospitality towards new rays of astonishing properties. Moreover Prof. Blondlot, the sponsor for the N rays, was not a man of unknown repute, but a physicist fifty-four years of age, whose name was attached to nearly two score of papers in the Comptes Rendus, who was elected correspondent of the Academy of Sciences to fill the vacancy caused by the death of Helmholtz, and to whom was awarded the Gaston Planté prize in 1893 for his studies in the propagation of electricity and again in 1899 the La Caze prize in physics. The estimation in which his ability was held by his fellow scientists of France is indicated by his association with the men named below to form the group of Correspondents in general Physics of the Academy of Sciences at the beginning of 1905,—Crova, Rayleigh, Bichat, Hittorf, van der Waals, Michelson, Gouy, Benoit, H. A. Lorentz.

Pellat and Girardet explicitly say that they accept the N rays because of Blondlot. The Revue Scientifique[206] says: "At the very first, when M. Blondlot announced his resounding discoveries, the universal reputation of this eminent physicist permitted no mind to fail to accept as facts definitely won for science the published results of his remarkable initial experiments." To this result the admirable style of the papers no doubt contributed.

The suggested explanations of the N-ray phenomena fall into four classes:

A. Deceit.
B. Physical Factors.
C. Physiological Factors.
D. Psychological Factors.

A. Deceit.

Of course no imputation of this character attaches to any of the scientific workers in the field of the Blondlot rays. It has, however, been suggested that Prof. Blondlot is himself the victim of the machinations of some one. "A solution is urgent and that for the good renown of the University of Nancy itself."[178]

B. Physical Factors.

1. Heat Radiation.—It may be that temperature changes play some part in the photographic methods of registering the effects of the N rays.[214]

Blondlot[29] as early as May, 1903, noted that the effect of his new rays on the phosphorescent screen is like that of heat and in his next paper[30] he guarded against the radiant heat of the sun falling upon his screen. In the paper[31] which followed this he establishes that the N rays cause no rise in temperature in bodies on which they fall. Later[41] he institutes a comparison between the effects of heat and of N rays on the phosphorescent screen. It was found that, while the N rays increase the quantity of light emitted normally to the surface and lessen the quantity emitted tangentially, heat on the other hand causes an increase in all directions. Further the contour of a key held in front of a phosphorescent screen is made sharper by letting N rays fall on the screen than by raising the temperature of the screen. This is true only when the line of sight is about normal to the screen. The reverse holds when the eye views the key obliquely.

Ballet[3] and Lambert[118] were at pains to avoid the effect of heat. Charpentier[64] maintains that the action of his physiological rays is not to be confounded with that of heat. The interposi-

tion of a sheet of aluminium or of a layer of water does not destroy the effects of the rays. A frog emits the rays even though below the temperature of the laboratory. D'Arsonval[210] tells that to avoid calorific effects experiments were performed in a room warmer than the human body, and that the usual results were obtained. Hooker[113] describes an experiment in which the physiological rays passed through the arm of a corpse and then acted on a screen.

After fruitless attempts to repeat Blondlot's and Charpentier's experiments had been made, recourse was had to heat effects for an explanation. Brown[146] states that he independently discovered zinc sulphide to grow brighter when brought near the human body, but that he later found the cause to be heat. Swinton[187,188,189] after failing in his first experiments afterwards found it easy to get results, but held heat to be the agent. A screen laid on the foot grew brighter, but a still warm boot was as effective. The imperviousness of water to the N rays is due, he supposes, to its adiathermancy.

Schenck,[184] McKendrick and Colquhoun,[173] Rothé[137] and Pieron[178] all agree that heat is important. Dufour[153] found temperature to modify the luminosity of the blue Ca S screen as well as that of the yellow Zn S screen. Bringing a finger near the screen makes it brighter. The bulbs of two identical thermometers were coated with Ca S. Both were exposed to light and then put in a dark room. When the temperature of one was raised from 12° to 28° it appeared more luminous. This faded as the thermometer cooled, so that at 20° it was only as bright as the other at 12°, and at 16° it was less bright. Hackett[111] found hot water (60°) to increase the brightness of the screen 5%.

The Revue Scientifique[206] makes the charge that the investigators of the new rays had not taken sufficient pains to guard against heat effects. This is certainly true in many instances.

2. Decay of Phosphorescence.—The emission of light from a phosphorescent body lessens as time passes. Schenck[184] suggests this as a factor in the results observed. This could have been subjected to control by comparing two identical screens, only one of which was acted on by the N rays.[206]

3. Change in the Distance of the Screen from the Observer.—Lullin[170,171] directs attention to the change in the appearance of the screen as depending on its distance from the eye.

C. Physiological Factors.

1. Tiring of the Eye.—This was suggested as an element in the problem by the Revue Scientifique.[206]

Pozdena[179] says that when the eye is tired the Ca S screen seems to approach and to recede and to be surrounded by a feebly luminous vapor.

La Roux[169] found that, if you look at the phosphorescent screen with one eye only, it grows darker. A time comes when obscure clouds pass over its surface. Some people see oscillations of brightness. The original appearance can be regained by exposing the eye to white light or by coughing or otherwise making a noise. This explains why Ballet[3] avoided speaking during an experiment. Blondlot[52] however regards the tiring of the eye as an obstacle to successful experimenting.

Hackett[111] remarks that resting that part of the retina receiving the image by closing the eyes or otherwise will cause an apparent increase of brightness.

2. Change of the Position of the Image on the Retina.—Hackett[111] says: "To an inexperienced persons a phosphorescent screen appears to be going through a series of bewildering variations. The greater part of these, if not all, are due to motions of the eye." When the image is transferred to an unwearied part of the retina the object looks brighter. He of course endeavored to train the eye to avoid this source of error.

In December, 1903, Lummer[172] directed attention to von Kries's theory of the function of the retinal rods and cones. In the *fovea centralis*, on which the image of an object falls when we look directly at it, only cones are found, while the rest of the retina has both cones and rods, the latter preponderating in the peripheral areas. The cones have to do with the sensation of color, while the rods are color-blind. They come into play in faint illuminations, furnishing a sensation of colorless light. Moreover their sensitiveness is more augmented in the dark than that of the cones. The owl has only rods in its eyes.

In direct vision only cones are concerned while rods also are affected in oblique vision.

When the temperature of a body is gradually raised there are two sharp changes.

a. From darkness to gray-glow, when the radiation is first sufficient to affect the rods.

b. From gray-glow to red-glow, when the radiation is first able to affect the cones.

If a platinum wire at 400° C. is looked at directly it cannot be seen, because its radiation is not sufficient to affect the cones of the *fovea centralis.* But if the eye is turned so that the image of the wire falls outside the *fovea centralis,* it becomes visible, since less energy is needed to excite the rods than the cones. According to Gotch[157] this effect can be seen in the spinthariscope.

Even when a body can be seen both by direct and by indirect vision its appearance is not the same in the two cases. It will appear brighter by indirect vision. The reader can verify this in the following manner: Fix the eyes on a very faint star, then turn the axis of the eyes slightly aside. The star will now appear brighter. Arago said: "To see the really difficult stars it is not necessary to regard them." Le Roux[120] says he failed to see the phosphorescent screen when he turned his eyes toward it, but did see it when he looked in a different direction. Lullin[170,171] made careful observations leading to the same result. He attributes the change, not to the difference between the rods and cones, but to the varying sensitiveness of the different parts of the retina. Chauveau[151] tells that one morning in a dark room he noticed a piece of paper. When he turned his eyes full upon it he could not see it. As the light grew stronger this phenomenon ceased. An observation made by Pozdena[179] is germane to the matter. When a Ca S screen is moving in a dark room with uniform speed in a straight line the eyes of the observer will follow its motion and he will see it by direct vision. If, however, the speed of the screen on the direction of its motion is changed, the eye does not at once follow the change and thus the image of the screen is no longer on the *fovea centralis* as it was in direct vision but is to one side of that spot. Hence an increase of brightness results, since the rods are more sensitive.

Many experiments made with the N rays present just such conditions as are needed to call forth the changes of appearance described above. Small feebly luminous surfaces are viewed in darkness. Involuntary motions of the eyes are frequent. Suppose that the dim surface of a phosphorescent screen is looked at and that the observer in the belief that a beam of N rays has been

falling upon the screen, now shifts a sheet of lead so as to cut off the beam. He expects an effect and to see it will look at the luminous surface more intently. This will bring the image upon the *fovea centralis* with its less sensitive cones. The image will thus appear less bright, and not only this, but it will appear reddish, since the image is transferred from the color-blind rods to the color sensitive cones. Platinum at 700° C. is red when viewed directly, but by indirect vision it is a peculiar colorless white, and is also brighter. If the observer removes the lead an unconscious shifting of the eyes will correspondingly change the position of the image, and he sees the screen as whiter as well as brighter than before.

In speaking of the change in the appearance of an image seen after reflection from a knitting needle when the N rays fall upon the latter, Blondlot[32] says: "It was then easy to establish that the action of these rays re-enforces the image, for, if they had just been intercepted, this image darkened and became reddish." Also in his examination of the action of a beam of polarized light on a small electric spark, he says (Paris, C.-R. Acad. Sci., 136, p. 487, Feb. 23, '03,): "It is instantly seen to weaken and to become reddish." When a large screen is used the whole of its image cannot fall on the *fovea centralis* and a change of appearance by shifting the eye will not be evident. It is significant that when Blondlot[41] used a relatively large screen, 5x12 cm., he failed to find its appearance changed by the N rays.

Lummer and Rubens [197] found that merely changing from direct to indirect vision made the brightness of the object viewed four times as great, while a change of only one-third in the intensity of a faint illumination is needed to be observed by a well adapted eye.

Throughout the literature of these rays there is frequent reference to the sluggishness with which the effects follow the beginning of the action of the rays.[29,30,31,32,33,34,36]

Blondlot[33] attributes this to storage effects. Broca[61] finds it to be lessened by the use of thin layers of Ca S in making the screen. On the other hand, Lummer[172] suggests that it may be explained by the time required to fix the eye.

Both Salvioni[183] and Nagel[175] are of the opinion that the position of the eye with respect to the object makes a difference in its appearance.

3. Change of Accommodation.—Blondlot[52] holds that accommodation must be avoided in order to see the effects of the N rays. H. Poincaré[210] attributes his own failure to see the effects he sought to involuntary accommodation. Ballet[3] strove to avoid change of accommodation. The Revue Scientifique[211] claims that when the accommodation is relaxed the pupil grows larger, thus allowing more light to enter the eye, with result of a brighter image. Moreover the effort not to accommodate will itself produce changes in the appearance of the phosphorescent screen.

Pointing in the opposite direction is the observation of McKendrick and Colquhoun[173] that the light of the screen became steady after accommodation had been relaxed.

4. Opening the Eyes to Varying Extents.—Ballet[4] warns against opening the eyes wider as this will allow more light to reach the retina.

5. Periodic Changes in the Curvature of the Lens of the Eye.—Heinrich and Chwistek[166] find that such changes cause a dark point on a white surface to appear and disappear at intervals.

D. Psychological Factors.

"The names of the physicists who have been the victims of such surprising illusions will remain imperishable, for works on psychology will repeat them from age to age."—Le Bon.[212]

1. Reaction of the State of Expectancy on the Muscles of the Eye.—McKendrick and Colquhoun[173] ask: "Can it be that the mental condition of some observers in a state of expectancy reacts on the intrinsic muscles of their eyes, and that they see what they think they should see?"

2. The Calling Up of One Sensation by the Presence of Another Which Usually Accompanies the First.—According to Rosenbach,[180] if, in a totally dark room the hand be moved in front of the well rested eye, either open or closed, the field of vision darkens and perhaps even the fingers appear to be visible. With a single finger before the eye its position, whether vertical or horizontal, can be seen. If a sheet of paper be held before the eyes the hand and fingers can no longer be seen. The muscular sensations produced by moving the hand call forth the accompanying visual image.

Testimony to the same effect is borne by Gehrcke.[156] He noted a change in the appearance of a phosphorescent screen when he moved a file behind it. The file at rest had no effect. The finger or a pencil acted as well as the file. Removing the screen did not keep the effect from appearing. The experiment succeeded best when the sound of the object scraping along the screen could be heard. When some other person moved the file nothing was seen.

Much emphasis is laid by Blondlot and others upon the necessity of the observer's manipulating his apparatus himself. It therefore seems very likely that when the observer moved an opaque screen into the path of the N rays his muscular sensations may have evoked optical ones which seemed objective to him.

3. Suggestion and Expectancy.

> "Of all the myriad moods of mind
> That through the soul come thronging,
> Which one was e'er so dear, so kind,
> So beautiful as Longing?"
>
> —*Lowell.*

A perusal of the literature of the N rays leads to the thought that the investigators often had the satisfaction of finding what they expected to find. Blondlot[29] found silver covered with soot to be a better radiator of N rays than when bright, and quartz to rotate the plane of polarization. Bagard[1] discovered the rotation of the plane of polarization of the N rays by tartaric acid to be in the direction indicated by theory. The law of Stokes for fluorescence is followed by the secondary radiation emitted by a body which has stored the N rays, according to Bichat.[22] The fact that a target can in general be reached by a projectile for two different elevations of a gun found its analog in the case of the heavy emission falling on the phosphorescent screen.[43] When Blondlot[34] found that N rays falling on the eye produced an effect upon the appearance of objects, he was astonished because, since water is opaque to the rays, he supposed the humors of the eye would absorb the rays before they reached the retina. Forthwith the difficulty is solved by finding that salt water is transparent to the rays.

Weiss[210] of Paris notes that Charpentier's determination of the wave-lengths of nervous impulses by use of his physiological rays gives about the same result as those obtained by the same

experimenter by another but faulty method. It seems not impossible that the results of the two methods were unwittingly made to agree.

It would, however, be totally unfair to give the impression that suggestion and expectancy as sources of error were overlooked by the workers with N rays, or that they always found what they looked for.

Blondlot[33,34] was astonished to find the appearance of a clock-face to change when N rays fell on the eye, and again to note that the phosphorescent screen continued to be affected by the N rays from a Welsbach light after it was extinguished. Bichat[19] found lead to be transparent to the rays, whereas his colleague, Blondlot, had found it opaque. J. Meyer[212] found many experimental results to run counter to his expectations. The path of the heavy emission proved not to be parabolic, as is approximately the case with projectiles. Surprise is manifested by Charpentier and Meyer[100,101] at certain phenomena they observed in inhibition, and by Macé de Lépinay in connection with his observations on sonorous vibrations.

Ballet,[4] Meyer,[126] Lambert [118] and Le Roux[120] tried to avoid the influence of expectancy upon their results.

In spite of this attitude of caution on the part of some of the investigators it is surprising how much stress is laid upon the necessity of the same persons both observing the effects and also setting in action the causes.

Broca[61] confesses: "I am deceived regularly when I do not operate the tube (containing Ca S) myself."

Upon Guinchant's[159] requesting Gutton to observe the spark while he took charge of intercepting the beam of N rays, the latter declined, saying that the method proposed would give no result as the eye does not perceive the variations of brightness when the mind is preoccupied with searching out the nature of the phenomena perceived.

Hackett's frankness is refreshing.[111] "It is a great obstacle in experiments in N rays that one does not know what change to expect." Wood[52] was warned by Blondlot that a person observing a phosphorescent screen could not necessarily tell when another threw the N rays on the screen. This was explained by the analogy of an observer watching a sensitive galvanometer. The image may be shifting, but, if the observer has the key for

closing the circuit in his own control, he can select a moment when the image is steady, close the key and thus find whether a current flows.

Some N ray workers adduce evidence in which the observer and the manipulator are distinct persons. Bichat[19] by using the N rays could tell the difference between a board painted with white lead and one covered with zinc white. Lambert[209] saw three persons pick out from six similar test tubes the one which emitted N rays. He himself several times detected the approach to the screen of an N ray source by his aid. Miller[132,134] and Macé de Lépinay[121,122] make similar claims. On the other side let it be remembered that when Wood substituted a piece of wood for a file or removed the refracting prism entirely the trained observer saw no change in the N ray phenomena.

Salvioni[183] believes suggestion to be most important. When he tried interposing screens of whose nature, whether opaque or transparent, he was ignorant, he found his results in the refraction of the N rays to lose their regularity. When Turpain[190] knew what to expect his results were like those of other investigators. He found the N ray effect in 81% of his trials. When, however, he had to rely upon his powers of observation, unaided by suggestion or expectation, the percentage fell to about 50.

In the development of the photographic plates used in connection with the spark experiments there is also room for unconscious prejudice in favor of one image. Perhaps Gutton's refusal[178] to have the plates developed by an impartial person points in this direction.

There was certainly no such conscientious and painstaking effort made by any one who believed in the N rays to avoid the effects of suggestion and of bias as was made by Pozdena[179] in his investigation of the heavy emission. He found no trace of evidence for its existence.

Burke's reference[149] to "an enthusiastic atmosphere which his (Blondlot's) experiments, his personality and strong convictions have created all around him," no doubt indicate the explanation of a large part of the N ray phenomena.

4. Hypnotic Sleep.—Sustained gaze at a small bright object is a means of inducing this state.—Burke.[147]

5. Unconscious Imitation of Previous Acts.—Pozdena[179] found that if he had already seen a phosphorescent screen bright

in a certain position he was more likely to see it bright in the same position again than elsewhere.

In Turpain's review[190] of Mascart's experiment he suggests that unconsciously giving the same number of equal impulses to a screw may account for the agreement between readings made by the same observer.

It would not seem difficult to devise a test by which the existence or non-existence of the N rays could be demonstrated. Debierne[208] suggested that a number of similar boxes be taken. In some of them let sources of N rays be placed. Let Blondlot in the presence of other physicists note the boxes from which the rays come. In pursuance of this suggestion the Revue Scientifique[216] in February, 1905, asked both Blondlot and Charpentier to assist in such a test. Both declined, the former saying: "The phenomena are much too delicate for that."

Wood[193] has suggested that Blondlot meet with Lummer and Rubens and that they together thresh out their disagreement as Pender and Cremieu did. This would certainly settle whether there is any effect produced upon the electric spark, which Blondlot maintains but which no one outside of France can find.

It is indeed unfortunate that "This affair of the N rays has raised in the French scientific world real passion."[221] After the death of Bichat his god-son Gutton, who had published papers on the N rays, was a candidate for the vacant professorship in physics in the University of Nancy. Turpain, whose results were adverse to the existence of the N rays, was also suggested for the position. The Revue Scientifique exerted its influence for the latter, but Gutton was named for the position.[223,224]

It is interesting to observe no hint of doubt in the existence of the N rays in the brief sketch of them given by Bouty in the third supplement to Jamin's Cours de Physique, 1906.[261]

In view of what has been said, it would indeed be wise to follow Faure's[154] suggestion that those who are to spend their lives in experimenting should receive instruction not alone in the technique of experimentation but in such allied sciences as will render the recurrence of a second N ray episode unlikely.

BIBLIOGRAPHY.

When more than one reference is given under one number it is to be understood that the papers are the same either verbatim or substantially.

An author's name is printed opposite only the first of his papers.

The abbreviations used are those of the International Catalog of Scientific Literature.

A. Papers Favorable to the Existence of the Various Rays.

1 Bagard, H.— Paris, C.-R. Acad. Sci., 138, p. 565, Feb. 29, 1904.
2 " " " " " 138, p. 686, Mch. 14, 1904.
3 Ballet, G— " " " " " 138, p. 524, Feb. 22, 1904.
4 Presse Méd., Paris, p. 169, March 16, 1904.
5 Ballet, G. and Delherm, L.—Rev. Neur., Paris, 12, p. 323, March 30, 1904.
Archives de Neurologie, (ser. 2), 17, p. 344, April, 1904.
6 Bechterew, W. M.—Rev. psychiatr. névrol. psychol. exp., St. Peterburg, 9, 1904.
Archives de Neurologie, (ser. 2), 19, p. 135, Feb., 1905.
7 Becquerel, Jean.—Paris, C.-R. Acad. Sci., 138, p. 1159, May 9, 1904.
8 " " " " " 138, p. 1204, May 16, 1904.
9 " " " " " 138, p. 1332, May 30, 1904.
10 " " " " " 138, p. 1415, June 6, 1904.
11 " " " " " 138, p. 1486, June 13, 1904.
12 " " " " " 138, p. 1586, June 20, 1904.
13 " " " " " 139, p. 40, July 4, 1904.
14 " " " " " 139, p. 264, July 25, 1904.
15 " " " " " 139, p. 267, July 25, 1904.
16 " " " " " 139, p. 416, Aug. 8, 1904.
17 Becquerel, Jean and Broca, André.—
Paris, C.-R. Acad. Sci., 138, p. 1280, May 24, 1904.
18 Bichat, E.— " " " " " 138, p. 329, Feb. 8, 1904.
19 " " " " " 138, p. 548, Feb. 29, 1904.
20 " " " " " 138, p. 550, Feb. 29, 1904.
21 " " " " " 138, p. 1254, May 24, 1904.
22 " " " " " 138, p. 1316, May 30, 1904.
23 " " " " " 138, p. 1395, June 6, 1904.
24 " " " " " 138, p. 1396, June 6, 1904.
25 " " " " " 139, p. 254, July 25, 1903.
26 Blondlot, R.— " " " " " 136, p. 284, Feb. 2, 1903.
J. phys., Paris, (ser. 4), 2, p. 169, March, 1903.
Physik, Zs., Leipzig, 4, p. 435, May 1, 1903.
27 Paris, C.-R. Acad, Sci., 136, p. 735, March 23, 1903.
J. phys., Paris, (ser. 4), 2, p. 339, May, 1903.
Physik, Zs., Leipzig, 4, p. 596, Aug. 15, 1903.
28 Paris, C.-R. Acad. sci., 136, p. 1120, May 11, 1903.
J. phys., Paris, (ser. 4), 2, p. 481, July, 1903.
Physik, Zs., Leipzig, 4, p. 598, Aug. 15, 1903.
29 Paris, C.-R. Paris, 136, p. 1227, May 25, 1903.

J. phys., Paris, (ser. 4), 2, p. 549, Aug., 1903.
Physik, Zs., Leipzig, 4, p. 599, Aug. 15, 1903.
30 Paris, C.-R. Acad. Sci., 136, p. 1421, June 15, 1903.
Physik, Zs., Leipzig, 4, p. 600, Aug. 15, 1903.
J. phys., Paris, (ser. 4), 2, p. 551, Aug., 1903.
31 Paris, C.-R. Acad. Sci., 137, p. 166, July 20, 1903.
32 " " " " " 137, p. 684, Nov. 2, 1903.
33 " " " " " 137, p. 729, Nov. 9, 1903.
34 " " " " " 137, p. 831, Nov. 23, 1903.
35 " " " " " 137, p. 952, Nov. 30, 1903.
36 " " " " " 137, p. 962, Dec. 7, 1903.
37 " " " " " 138, p. 125, Jan. 18, 1904.
Eclair. électr., Paris, 38, p. 274, Feb. 13, 1904.
38 Paris, C.-R. Acad. Sci., 138, p. 453, Feb. 22, 1904.
39 " " " " " 138, p. 545, Feb. 29, 1904.
40 " " " " " 138, p. 547, Feb. 29, 1904.
41 " " " " " 138, p. 665, Mar. 14, 1904.
42 " " " " " 138, p. 1394, June 6, 1904.
43 " " " " " 138, p. 1473, June 13, 1904.
44 " " " " " 138, p. 1675, June 27, 1904.
45 " " " " " 138, p. 1676, June 27, 1904.
46 " " " " " 139, p. 22, July 4, 1904.
47 " " " " " 139, p. 114, July 11, 1904.
48 " " " " " 139, p. 843, Nov. 21, 1904.
49 J. phys., Paris, (ser. 4), 3, pp. 5, 121, 257, 1904.
50 Arch. Sci. Phys., Genève, (ser. 4), 17, p. 473, May 15, 1904.
51 Electr., London, 52, p. 830, March 11, 1904.
52 Rev. sci., Paris, (ser. 5), 2, p. 620, Nov. 12, 1904.
Sci. Amer. Sup., New York, N. Y., 58, p. 24211, Dec. 17, 1904.
53 Rev. gén. sci., Paris, 16, p. 727, Aug. 30, 1905.
54 Nancy, Bul. soc. sci., (ser. 3), 4, p. 144, May-June, 1903.
55 Rayons "N," Paris, 1904, Gauthier-Villars. This book contains Blondlot's papers from Paris, C.-R. Acad. Sci., up to March 14, 1904. Pp. 78. Translated into English by J. Gracin, London, 1905. Longmans, Green and Co. Pp. 83.
Reviews of these books in
56 Nature, London, 72, p. 195, June 29, 1905.
57 Physik, Zs., Leipzig, 5, p. 560, Sept. 1, 1904.
58 Bohn, G.— Paris, C.-R. soc. biol., 55, p. 1694, Jan. 1, 1904.
59 Bordier, H.— Paris, C.-R. Acad. sci., 139, p. 972, Dec. 5, 1904.
Rev. sci., Paris (ser. 2), 5, pp. 783 and 792, Dec. 17, 1904.
60 Breydel, A.— Eclair. électr., Paris, 41, p. 325, Nov. 26, 1904.

61 Broca, André.— Paris, C.-R., Acad. sci., 138, p. 1161, May 9, 1904.
62 Arch. électr., méd. exp., Paris, 12, p. 723, Oct. 10, 1904.
An abstract of the paper appeared in the three following:
Elec. World Engin., New York, N. Y., 44, p. 909, Nov. 26, 1904.
Electr., London, 54, p. 58, Oct. 28, 1904.
Science Abstracts, 7, A, p. 961, 1904.
Broca, André, Becquerel, J. and—see Becquerel, Jean and Broca André.
63 Broca, André and Zimmern, A.—
Paris, C.-R., Acad. sci., 138, p. 1239, May 16, 1904.
64 Charpentier, Augustin.—
Paris, C.-R. Acad. sci., 137, p. 1049, Dec. 14, 1903.
65 " " " " " 137, p. 1277, Dec. 28, 1903.
66 " " " " " 138, p. 45, Jan. 4, 1904.
67 " " " " " 138, p. 194, Jan. 25, 1904.
68 " " " " " 138, p. 270, Feb. 1, 1904.
69 " " " " " 138, p. 414, Feb. 15, 1904.
70 " " " " " 138, p. 584, Feb. 29, 1904.
71 " " " " " 138, p. 648, Mar. 7, 1904.
72 " " " " " 138, p. 648, Mar. 7, 1904.
73 " " " " " 138, p. 715, Mar. 14, 1904.
74 " " " " " 138, p. 772, Mar. 21, 1904.
75 " " " " " 138, p. 919, Apr. 11, 1904.
76 " " " " " 138, p. 1121, May 2, 1904.
77 " " " " " 138, p. 1163, May 9, 1904.
78 " " " " " 138, p. 1282, May 24, 1904.
79 " " " " " 138, p. 1351, May 30, 1904.
80 " " " " " 138, p. 1540, June 13, 1904.
81 " " " " " 138, p. 1723, June 27, 1904.
82 " " " " " 139, p. 155, July 11, 1904.
83 Paris, C.-R. soc. biol., 55, p. 1677, Dec. 25, 1903.
84 " " " " " 56, p. 69, Jan. 22, 1904.
85 " " " " " 56, p. 273, Feb. 19, 1904.
86 " " " " " 56, p. 276, Feb. 19, 1904.
87 " " " " " 56, p. 527, Mar. 25, 1904.
88 " " " " " 56, p. 528, Mar. 25, 1904.
89 " " " " " 56, p. 531, Mar. 25, 1904.
90 " " " " " 56, p. 727, May 6, 1904.
91 " " " " " 56, p. 826, May 27, 1904.
92 " " " " " 56, p. 828, May 27, 1904.
93 " " " " " 56, p. 1045, June 24, 1904.
94 " " " " " 56, p. 1047, June 24, 1904.
95 " " " " " 56, p. 1049, June 24, 1904.
96 " " " " " 57, p. 148, July 22, 1904.
97 " " " " " 57, p. 150, July 22, 1904.
98 Arch. électr. méd. exp., Paris, Jan. 25, 1904.

99 Paris, Bul. séan. soc. franç. phys., 4th Fascicule, p. 32,* 1904.

Charpenter, A., and Meyer Édouard.

100 Paris, C.-R. Acad. sci., 138, p. 520, Feb. 22, 1904.
101 " " " " " 138, p. 832, Mar. 28, 1904.
102 Colson, Albert.— Paris, C.-R. Acad. sci., 138, p. 902, Apr. 11, 1904.
103 " " " " " 138, p. 1098, May 2, 1904.
104 " " " " " 138, p. 1423, June 6, 1904.
105 " " " " " 139, p. 199, July 18, 1904.
106 " " " " " 139, p. 857, Nov. 21, 1904.
106a Paris, Bul., séan. soc. franç. phys., p. 32*, 1906.

Delherm, L., Ballet, G. and—see Ballet, G. and Delherm, L.

107 Garcia, G. J. de G.—Memorias de la Real Academia de Ciencas y Artes de Barcelona (ser. 3), 5, p. 180, No. 14, Oct., 1905.
108 Gutton, C.— Paris, C.-R. Acad. sci., 138, p. 1592, June 20, 1904.
109 " " " " " 142, p. 142, Jan. 15, 1906.
110 Paris, C.-R. ass. franç. avanc. sci. Aug. 4, 1905.
111 Hackett, F. E.—Dublin, Sci. Trans. R. Soc., (ser. 2), 8, p. 127, Sept., 1904.
Abstract in Nature, London, 70, p. 167, June 16, 1904.
" " 70, p. 583, Oct. 13, 1904.
Ann. Physik., Beibl., Leipzig, 28, p. 1255, —, 1904
112 Hooker, J. S.—Lancet, London, I, p. 686, Mar. 5, 1904.
113 " " II, p. 1380, Nov. 12, 1904.
114 Jegou, P.—Paris, C.-R. Acad. sci., 138, p. 491, Feb. 22, 1904.
115 Kotik, N. G.—Rev. psychiatr, névrol. psychol. exp., St. Peterburg, 9, 1904.
Archives de Neurologie, (ser. 2), 19, p. 135, Feb., 1905.
116 Lambert, M.—Paris, C.-R. Acad. sci., 138, p. 196, Jan. 25, 1904.
117 " " " " " 138, p. 626, Mar. 7, 1904.
118 Paris, C.-R. soc. biol., 56, p. 334, Mar. 4, 1904.

Lambert, M., Meyer, E. and—see Meyer, E. and Lambert, M.

119 Lambert, M. and Meyer, E.—
Paris, C.-R. Acad. sci., 138, p. 1284, May 24, 1904.
120 Le Roux, F. P.— " " " " " 139, p. 270, July 25, 1904.
121 Macé de Lepinay, J.— " " " " " 138, p. 77, Jan. 11, 1904.
122 " " " " " 138, p. 798, Mar. 28, 1904.
123 Mascart, E. L.— " " " " " 142, p. 122, Jan. 15, 1906.
124 Meyer, Edouard.— " " " " " 138, p. 101, Jan. 11, 1904.
125 " " " " " 138, p. 272, Feb. 1, 1904.
126 Paris, C.-R. soc. biol. 56, p. 72, Jan. 22, 1904.
127 " " " " " 56, p. 278, Feb. 19, 1904.

Meyer, E., Charpentier, A. and—see Charpentier, A. and Meyer, E.—

Meyer, E., Lambert, M. and—see Lambert, M. and Meyer, E.—

128 Meyer, E. and Lambert, M.—
Paris, C.-R. soc. biol., 56, p. 843, June 3, 1904.

129 Meyer, Julien.—Paris, C.-R. Acad. sci., 138, p. 896, Apr. 11, 1904.
130 " " " " " 138, p. 1335, May 30, 1904.
131 " " " " " 138, p. 1491, June 13, 1904.
132 " " " " " 139, p. 320, July 25, 1904.
133 Miller, Leslie.—Electr., London, 52, p. 788, Mar. 4, 1904.
134 Lancet, London, I, p. 1150, Apr. 23, 1904.
Miller, Leslie, Walsham, Hugh and—see Walsham, Hugh and Miller, Leslie.
134a Munro, John.—Lancet, London, I, p. 1682, Apr. 16, 1904.
134b Niven, C. R.— " " II, p. 1449, Nov. 19, 1904.
135 Raoult, Aimar.—Ann. malad. oréille, Paris, 30, Part. I, p. 587, June, 1904.
" ibid, 30. Part 2, p. 461, Nov., 1904.
136 Richet, Charles—Paris, C.-R. Acad. sci., 138, p. 588, Feb. 29, 1904.
137 Rothé, E.— " " " " " 138, p. 1589, June 20, 1904.
138 Sagnac, G.— " " " " " 136, p. 1435, June 15, 1903.
J. phys., Paris, (ser. 4), 2, p. 553, Aug. 1903.
Paris, Bul. séan. soc. franç. phys., p. 173, 1903.
" " " " " " 4th Fascicule, p. 46,* 1903.
Physik, Zs., Leipzig, 4, p. 601, Aug. 15, 1903.
Walsham, Hugh and Miller, Leslie.—
139 Lancet, London, I, p. 610, Feb. 27, 1904.
140 " " I, p. 831, Mar. 19, 1904.
141 Zimmern, A., Broca, André, and—see Broca, André, and Zimmern, A.

B. Criticisms, Records of Failure, Explanations, Allied Phenomena.

142 Axmann— Himmel u. Erde, Berlin.—18, 1906.
143 Basler, H. and Peters, W.—Physik. Zs., Leipzig, 6, p. 411, July 1, 1905.
144 Baumhauer, H— " " " 5, p. 289, June 1, 1904.
145 Bellia, C.—Catania, Bull. Acc. Gioenia, 86, May 1905.
Ann. Physik. Beibl., Leipzig, 30, p. 1143, 1906.
146 Brown, S. G.—Nature, London, 69, p. 296, Jan. 28, 1904.
Bull, L. and Weiss, G.—See Weiss, G. and Bull, L.
147 Burke, J. B.—Nature, London, 69, p. 365, Feb. 18, 1904.
148 " " 70, p. 198, June 30, 1904.
149 Electr., London, 54, p. 323, Dec. 9, 1904.
150 Chanoz, M. and Perrigot, M.—
Paris, C.-R. Acad. sci., 140, p. 86, Jan. 9, 1905.
Rev. sci., Paris, (ser. 2), 5, p. 84, Jan. 21, 1905.
151 Chauveau, A.— Paris, C.-R. Acad. sic., 140, p. 761, Mar. 20, 1905.
Chwistek, L., and Heinrich W.—See Heinrich W. and Chwistek L.
Colquhoun, W.: McKendrick, J. G. and—see McKendrick, J. G. and Colquhoun, W.
152 Cotton and Raveau.—
Paris, Bul. soc. franç phys., No. 242, p. 5, Mar. 8, 1906.

Revue du Mois, 1906, p. 503, Apr. 10.
Rev. sci., Paris, (ser. 5), 5, p. 376, Mar. 24, 1906.
153 Dufour, Henri.—
Arch. Sci. Phys., Genève, (ser. 4), 18, p. 201, Aug. 15, 1904.
Rev. sci., Paris, (ser. 5), 2, p. 338, Sept. 10, 1904.
154 Faure, Louis.—Archives de Neurologie, (ser. 2), 19, p. 396, May, 1905.
155 Gebhardt. M.—Dresden, Sitz, Ber. Isis., 1906, p. 3, Jan.-June.
156 Gehrcke, E.—Physik, Zs., Leipzig, 6, p. 7, Jan. 1, 1905.
157 Gotch, Francis.—Nature, London, 72, p. 174, June 22, 1905.
158 Guilleminot, H.—Arch. électr. méd. exp., Paris, 13, p. 243, Apr. 10, 1905.
Science Abstracts, 8A, p. 420, 1905.
159 Guinchant, J.—Rev. sci., Paris, (ser. 5), 5, p. 55, July 14, 1906.
160 Gutton, C.—Paris, C.-R. Acad. sci., 138, p. 268, Feb. 1, 1904.
161 " " " " " 138, p. 352, Feb. 8, 1904.
163 " " " " " 138, p. 568, Feb. 29, 1904.
164 " " " " " 138, p. 963, Apr. 18, 1904.
165 J. phys., Paris, (ser. 4), 3, p. 341, May, 1904.
166 Heinrich, W. and Chwistek, L.—Zeitschrift für Sinnesphysiologie, 41, p. 59, 1906.
167 Hennig.—Natw, Wochenschr. Jena., 20, p. 507, Aug. 6, 1905.
168 de Hemptinne, A.—Paris, C.-R., 138, p. 754, Mar. 21, 1904.
169 Le Roux, F. P.— " " " 138, p. 1413, June 6, 1904.
170 Lullin, Th.— " " " 140, p. 1059, Apr. 10, 1905.
171 Arch. Sci. Phys., Genève, (ser. 4), 19, p. 409, April 15, 1905.
172 Lummer, O.—Berlin, Ber. D. physik. Ges., p. 416, Dec. 15, 1903.
Physik, Zs., Leipzig, 5, p. 126, Mar. 1, 1904.
Nature, London, 69, p. 378, Feb. 18, 1904.
173 McKendrick, J. G. and Colquhoun, W.—Nature, London, 69, p. 534, Apr. 7, 1904.
174 Mercanton, P. L. and Radzikowski, C.—
Paris, C.-R. Acad. sci., 138, p. 1541, June 13, 1904.
Arch. Sci. Phys. Genève., (ser. 4), 18, p. 507, Oct. 15, 1904.
175 Nagel, W. A.—Fortschr. Med., Berlin, 22, p. 402, Mar. 20, 1904.
176 Pacini, D.—Nature, London, 70, p. 107, June 2, 1904.
Perrigot, M., Chanoz, M. and—see Chanoz, M. and Perrigot, M.
177 Perrin, J.—Rev. sci., Paris, (ser. 5), 5, p. 216, Feb. 17, 1906.
Revue du Mois, p. 255, Feb. 10, 1906.
Peters, W., Basler, H. and—see Basler, H. and Peters W.
178 Pieron, H.—Rev. sci., Paris, (ser. 5), 5, p. 504, April 21 1906.
179 Pozdena, R. F.—Ann. Physik., Leipzig, 17, p. 104, June, 1905.
Radzikowski, C., Mercanton, P. L. and—see Mercanton, P. L. and Radzikowski, C.
Raveau, Cotton and—see Cotton and Raveau.
180 Rosenbach, O.—Physik. Zs., Leipzig, 6, p. 164, Mar. 15, 1905.
181 Rubens, H.—Rev. sci., Paris, (ser. 5), 2, p. 753, Dec. 10, 1904.
182 Rudge, W. A. D.—Nature, London, 69, p. 437, Mar. 10, 1904.

183 Salvioni, E.—
Roma, Rend. Acc. Lincei., (ser. 5), 13, [1], p. 610, June 4, 1904.
" " " " p. 703, June 19, 1904.
Nuovo Cimento, Pisa, (ser. 5), 8, p. 141, Aug., 1904.
Ann. Physik., Beibl., Leipzig, 28, 1254, 1904.
Science Abstracts, 7A, p. 783, 1904.
Rev. sci., Paris, (ser. 5), 2, p. 73, July 16, 1904.
" " " (ser. 5), 2, p. 152, July 30, 1904.
184 Schenck, C. G.—Nature, London, 69, p. 486, Mar. 24, 1904.
185 Stefanelli, P.—Napoli, Rend. Acc. sc., (ser. 3a), 11, p. 463, Dec., 1905.
Nature, London, 74, p. 17, May 3, 1906.
Rev. sci., Paris, (ser. 5), 5, p. 606, May 12, 1906.
186 Swinton, A. A. C.—Nature, London, 69, p. 272, Jan. 21, 1904.
Elect., London, 52, p. 540, Jan. 22, 1904.
187 . " " 52, p. 746, Feb. 26, 1904.
Nature, London, 69, p. 412, Mar. 3, 1904.
188 Lancet, London, 1904, I, p. 685, Mar. 5.
189 Nature, London, 73, p. 413, Mar. 1, 1906.
Elect., London 56, p. 809, Mar. 2, 1906.
Rev. sci., Paris, (ser. 5), 5, p. 311, Mar. 10, 1906.
190 Turpain, A.—J. phys., Paris, (ser. 4), 5, p. 343, May, 1906.
Paris, Bul.. Séan. soc. franç. phys., 1906, p. 94
Paris, Bul. Séan. Soc. franç. phys., 31*, 1906.
Rev. sci., Paris, (ser. 5), 5, p. 471, Apr. 14, 1906.
" " " " " 5, p. 491, Apr. 21, 1906.
191 Weiss, G.— " " " " " 2, p. 785, Dec. 17, 1904.
192 Weiss, G. and Bull, L.—
Paris, C.-R. Acad. sci., 139, p. 1028, Dec. 12, 1904
193 Wood, R. W.—Nature, London, 70, p. 530, Sept. 29, 1904.
Elec. Rev., New York, N. Y., 45, p. 630, Oct. 15, 1904.
Rev. sci., Paris, (ser. 5), 2, p. 536, Oct. 22, 1904.
Physik. Zs., Leipzig, 5, p. 789, Dec. 1, 1904.
Sci. Amer. Sup., New York, N. Y., 58, p. 24210, Dec. 17, 1904.
194 Zahn, H.—Physik. Zs., Leipzig, 4, p. 868, Dec. 15, 1903.
Discussion of N rays at
195 *a* Cassel Naturforscherversammlung, Sept. 20, 1903.
Physik, Zs., Leipzig, 4, p. 732, Oct. 24, 1903.
Verh. Ges. D. Natf., Leipzig, 2nd Part, 1st Half, p. 38, 1903.
196 *b* Breslau Naturforscherversammlung, Sept. 20, 1904.
Physik, Zs., Leipzig, 5, p. 674, Oct. 20, 1904.
Chem. Ztg. Cöthen, p. 928, Sept. 28, 1904.
Natw. Rdsch., Braunschweig, p. 569, Nov. 3, 1904.
Verh. Ges. D. Natf., Leipzig, 2nd Part, 1st Half, p. 89, 1904.
197 *c* British Association for the Advancement of Science, Cambridge. Aug. 22, 1904.
Report B. A. A. S., p. 467, 1904.

198 *d* Sixth International Congress of Physiology, Brussels, Aug. 31 to Sept. 3, 1904.
Rev. sci., Paris, (ser. 5), 2, p. 548, Oct. 29, 1904.

ARTICLES IN REV. SCI., PARIS.

199 (Ser. 5), 1, p. 731, June 4, 1904.
200 " " 1, p. 795, June 18, 1904.
201 " " 2, p. 59, July 9, 1904.
202 " " 2, p. 60, July 9, 1904.
203 " " 2, p. 152, July 30, 1904.
204 " " 2, p. 338, Sept. 10, 1904.
205 " " 2, p. 536, Oct. 22, 1904.
206 " " 2, p. 545, Oct. 29, 1904.
207 " " 2, p. 590, Nov. 5, 1904.
208 " " 2, p. 620, Nov. 12, 1904.
209 " " 2, p. 656, Nov. 19, 1904.
210 " " 2, p. 682, Nov. 26, 1904.
211 " " 2, p. 705, Dec. 3, 1904.
212 " " 2, p. 718, Dec. 3, 1904.
213 " " 2, p. 731, Dec. 3, 1904.
214 " " 2, p. 752, Dec. 10, 1904.
215 " " 2, p. 783, Dec. 17, 1904.
216 " " 5, p. 129, Feb. 3, 1906.
217 " " 5, p. 216, Feb. 17, 1906.
218 " " 5, p. 376, Mar. 24, 1906.
219 " " 5, p. 471, Apr. 14, 1906.
220 " " 5, p. 510, Apr. 21, 1906.
221 " " 6, p. 30, July 7, 1906
222 " " 6, p. 55, July 14, 1906.
223 " " 6, p. 59 " ", 1906.
224 " " 6, p. 186, Aug. 11, 1906.

225 There is a brief account of the French discussion in the Literary Digest, 29, p. 840, Dec. 17, 1904.

C. EDITORIAL COMMENTS, CLAIMS OF PRIORITY, ETC.

226 D'Arsonval.—Paris, C.-R. Acad. sci., 138, p. 884, Apr. 11, 1904.
227 Audollent, P.—Paris, C.-R. Acad. sci., 137, p. 1227, Dec. 28, 1903.
228 Baraduc, H. " " " " " 138, p. 34, Jan. 4, 1904.
229 Bose, E.—Physik. Zs., Leipzig, 5, p. 560, Sept. 1, 1904.
230 Darget.—Paris, C.-R. Acad. sci., 138, p. 189, Jan. 25, 1904.
231 Dubois, Raphael.—Paris, C.-R. soc. biol., 56, p. 149, Feb. 5, 1904.
232 Etges, M. P.—Paris, C.-R. Acad. sci., 140, p. 696, Mar. 6, 1905.
233 Galtier, C.— " " " " " 138, p. 115, Jan. 11, 1904.
234 Huter, C.— " " " " " 138, p. 34, Jan. 4, 1904.
235 McKendrick, J. G.—Nature, London, 72, p. 195, June 29, 1905.
236 Award of Le Conte Prize to R. Blondlot.—
Paris, C.-R. Acad. sci., 139, p. 1120, Dec. 19, 1904.

Editorial comment will be found in the following:

237 Cosmos, p. 704, Dec. 3, 1904.
238 Eclair, électr., Paris, 40, p. L, 1904.
239 Elec. World Engin., New York, N.Y., 41, p. 1086, June 27, 1903.
240 42, p. 1034, Dec. 26, 1903.
241 44, p. 51, July 9, 1904.
242 45, p. 128, Jan. 21, 1905.
243 Elec., London.—51, p. 313, June 12, 1903.
244 51, p. 649, Aug. 7, 1903.
245 52, p. 276, Dec. 11, 1903.
246 52, p. 591, Feb. 5, 1904.
247 52, p. 676, Feb. 19, 1904.
248 52, p. 848, Mar. 18, 1904.
249 53, p. 676, Aug. 12, 1904.
250 54, p. 296, Dec. 9, 1904.
251 Lancet, London, 1904, I, p. 526, Feb. 20, 1904.
252 " " 1904, I, p. 611, Feb. 27, 1904.
253 " " 1904, I, p. 1082, Apr. 16, 1904.
254 Rev. psychiat., Paris, (ser. 4), 9, p. 129, Mar., 1905.
255 Sci. Amer. Sup., New York, N. Y., 61, p. 25415, May 26, 1906.

D. Resumes.

256 Abbot, C. G.—Washington, D. C., Smithsonian Inst., Rep., 1903, p. 207.
Sci. Amer. Sup., New York, N. Y., 59, p 24600.
257 Angenheister, G.—Prometheus, Berlin, 15, pp. 625 and 641, 1904.
258 Ascoli, M.—Rev. gén. sci., Paris, 15, p. 226, Mar. 15, 1904.
259 Berget, A.—Le Radium et les Nouvelles Radiations (Rayons X et Rayons N). Paris, 1904. Libraire universelle.
Blondlot, R.—See No. 55.
260 Bordier, H.—Les Rayons N et les Rayons N_1, Paris, 1905, J. B. Baillière et Fils, pp. 95, 16 figures.
Lancet, London, I, 1905, p. 30, Jan. 7.
261 Bouty, E.—Cours de Physique de l' École Polytechnique, J. Jamin Troisième supplement. Radiations, Électricite. Ionisation, Paris, Gauthier-Villars, 1906.
Nature, London, 74, 147, June 14, 1906.
262 Dieckmann, M.—Prometheus, Berlin, 15, p. 49, 1903.
263 Duncan, R K.—Harper's Monthly Magazine, 110, p. 675, Apr., 1905.
264 Ewald, P. P.—Prometheus, Berlin, 16, p. 174, 1904.
265 Garcin, J.—See Blondlot, No. 55.
Electrical Magazine, 3, p. 452, May 23, 1905.
" " 3, p. 521, June 27, 1905.
" " 4, p. 235, Oct. 28, 1905.
266 Meyer, Hans.—Blondlots N-Strahlen. R. Papauschek, Maehr-Ostrau. 1904, 38 pp.
Physik. Zs., Leipzig, 6, p. 124, Feb. 15, 1905.
267 Piper, H.—Zs. Psychol., Leipzig, 37, p. 386, 1905.

268 Proumen, H.—Les rayons X, le Radium, les rayons N. H. Desforges, Paris, 1905.
Le Radium, 2, p. 2, Supplement, Dec. 15, 1905.
269 Rainay, H.—Scot. Med. Surg. J., Edinburgh, 14, p. 355, April, 1904.
270 Romilli, E.—Human Radiations. "N." Rays. London, Doughty, 1904.
271 Stewart, J. J.—Knowledge and Scientific News, 2. pp. 218 and 242, Sept. and Oct., 1905.
272 de Tunzelman, G. W.—Electrical Magazine, 1, p. 182, Feb. 25, 1904.
273 Vitoux, G.—Presse Méd., Paris, p. 67, Jan. 30, 1904.
274 Whitehead, J. B.—Elec. Rev., New York, N. Y., 44, p. 433, Mar. 19, 1904.
See Résumés in Zs. physik. Unterr., Berlin.
275 16, pp. 226, 354, 1903.
276 17, p. 164, , 1904.
277 18, pp. 99, 358, 1905.
278 Himmel u Erde, Berlin, 17, p. 88, 1905.
Summaries of many articles will be found in
Ann. Physik. Beibl., Leipzig.
Eclair. électr., Paris.
Electrical Magazine.
Elect., London.
Elec. World Engin., New York, N. Y.
Fortschritte der Physik.
Lancet, London.
Presse méd., Paris.
Natw. Rdsch., Braunschweig.
Physikalisch-chemisches Centralblatt.
Rev. neur., Paris.
Rev. sci., Paris.
Science Abstracts, A.
Sci. Amer., New York, N. Y.
Sci. Amer. Sup., New York, N. Y.

ACCORDING to the *Electrical Review* investigation has shown that various alloys of manganese, copper and aluminum possess magnetic properties, although they contain no metal of the so-called magnetic group. These alloys have upset the theory of magnetism formerly held. The most promising view now is that magnetism is a molecular property, a property of groups of atoms or groups of molecules rather than of single atoms alone.

ACCORDING to the statistics presented by F. Z. Shellenberg before the Engineers' Society of Western Pennsylvania, 67 per cent. of the accidents in Pennsylvania coal mines are due to falls of roofs and sides, while only 9 per cent. are due to gas and 4 per cent. to explosives.—*Eng. and Min. Jour.*

THE Brazilian Government is about to levy a heavy export tax upon monazite sand, which will affect the incandescent gas mantle industry generally.—*London Engineer.*

INVESTIGATION OF STEEL-HARDENING METALS.

So many investigations have been carried on in connection with the manufacture of crucible steel and of high-speed tool steel that further advance in this direction would seem most improbable, but the combination of other metals with steel has now fully shown that they give it specific properties that adapt it especially to particular uses.

The known steel-hardening metals, named in order of importance of production and use, are nickel, chromium, manganese, tungsten, molybdenum, vanadium, titanium, cobalt, and uranium. The value of these metals produced in the United States in 1906 amounted to $458,327, of which $393,667 was for tungsten. The price of tungsten, which has been increasing for a number of years, was quoted at $5 to $6 per unit (1 per cent. of a ton) in 1905, and at $12 per unit in the spring of 1907. Only small quantities are at present imported into the United States, as European markets utilize practically all that is produced in foreign localities, mostly in Peru and Australia. Large deposits of tungsten are found in Australia, and it is not improbable that sufficient may be obtained there to permit a cetain portion of it to be shipped to the United States, but for the present this country will have to look within its own borders for sources of supply.

The increased demand for the steel-hardening metals has stimulated prospecting for the ores in the United States, and information concerning them is eagerly sought. So many inquiries have reached the United States Geological Survey that a special investigation of the subject has been planned, which has been assigned to Frank L. Hess. In the course of this work, which will extend throughout the summer and into the fall, Mr. Hess will visit South Dakota Idaho, Colorado, Montana, Washington, Oregon, California, Nevada, Utah, and Arizona. The results of Mr. Hess' work will be reported in a bulletin on the steel-hardening metal deposits other than manganese.

INVESTIGATIONS OF LIME-PHOSPHATE DEPOSITS OF THE WEST.

The extensive exploration and development work now being done on the lime-phosphate deposits in Idaho, Oregon, and Utah afford an opportunity for a detailed geologic study of phosphate deposits that will be used to great advantage by the United States Geological Survey. The pits and trenches dug to determine the position and character of the beds must be studied while still freshly made, as they rapidly become filled with débris from the surface, which renders their examination difficult.

F. B. Weeks, of the Survey, who made a preliminary study of some of the workings last fall, will begin field work about the middle of August and continue it until the middle of October or later. The deposits occur over considerable areas in southeastern Idaho, southwestern Wyoming, and northeastern Utah, and prospecting has been carried on at a number of widely separated localities. Beds that are of good grade but too thin to be profitably worked have also been discovered in Nevada, and it is probable that further exploration will show that these phosphates have a wide distribution.

A Convenient Means of Determining the Ash in Graphite

By S. S. Sadtler,

Member of the Institute.

Very recently the writer had occasion to make a number of tests of the mineral residue (and total carbon) of a number of samples of flake graphite of different degrees of fineness. It happened that the analyses had to be finished with considerable rapidity, but the residue had to be left in such a condition that it could be analyzed for iron oxide and silica.

Mr. P. B. Sadtler suggested that it might be done by using the inner crucible, described by the writer in a paper on* "The Determination of Sulphur in Halogens in Organic Substances." The reason for selecting this form of crucible was that it was narrowed from the bottom to the top, so that the cross section of the opening was much less than the bottom of the crucible. The measurements of a small crucible were: Diameter of the opening, 15 millimeters; diameter of the bottom, 25 millimeters; measurement of side, 40 millimeters.

The amount of graphite weighed out for analysis was about one-third of a gram. It was found that with the very fine flakes, that the heat of combustion was so great that the residue fused, and while this did not interfere with the determination of the total amount of the residue, it made it hard to remove it from the crucible and analyze it.

It was therefore found necessary to mix a small amount of carefully ignited magnesia with the finer flaked grades. The amount used, however, was only about twenty milligrams. In the coarser grades a little magnesia was also used, but the amount was only about five milligrams, as more magnesia rendered it more difficult to burn completely.

In carrying out the analysis, the amount mentioned was weighed into the crucible, containing the requisite amount of mag-

*Jour. Am. Chem. Soc., XXVII, Sept., '05, p. 1188.

nesia. These were then intimately mixed and shaken down to a small pile in the bottom of the crucible, when tipped at an angle of about 30°, or as found convenient for burning. It is then placed upon a platinum triangle, over an ordinary blast lamp, so that the combustion might be started and more or less regulated thereafter.

The chief precautions found necessary to completely burn the graphite were to prevent blowing out either the graphite or the ash with the current of oxygen, and to keep the mass together and continually burning, as light flakes driven to other parts of the crucible would take some time to become consumed.

It was, therefore, found desirable to get a suitable stream of oxygen, which was delivered to the crucible by means of a clay pipe stem, and hold it first at the opening, to gradually bring it in, and run it over the surface, so as to slightly sinter it. Then, beginning at one edge, to gradually bring the combustion through the mass, keeping the temperature at very bright incandescence, the observer using cobalt glass for protection to his eyes. When no more bright indication of combustion is perceptible, all graphite should be consumed, but it is well to keep a small stream of oxygen playing into the crucible for five or ten minutes, to be sure of the reaction being completed.

When the analyses were first started, duplicate determinations were made on about six grades, which showed but slight variation, namely up to about .3%, based upon the sample taken. The writer did not expect to publish results at the time, and cannot give figures except those selected as the results taken.

These are given as follows, and show a rather uniform gradation of the total carbon in the separations of a practical manufacturer.

The first series are comparisons of the same grading, but some difference in the manner of separation:

SERIES NO. 1.

	No. 1 Crucible.	No. 2 Crucible.	1-19 Dust.	2-19 Dust.
Ash	5.07	7.46	33.70	60.25
Carbon	94.93	92.54	66.30	39.75

SERIES NO. 2.

	No. 1 Crucible.	No. 2 Crucible.	1-19 Dust.	2-19 Dust.
Ash	5.76	6.52	12.93	42.30
Carbon	94.24	93.48	87.07	57.70

SERIES NO. 3.

	No. 1 Lub.	No. 1 Lub.	50 Flake.	75 Flake.	100 Flake.	130 Flake	150 Flake.
Ash.....	2.65	6.16	7.93	10.60	15.50	18.20	33.10
Carbon.....	97.35	93.84	92.17	89.40	84.50	81.80	66.90

With regard to the oxygen used, it is probable that any good commercial grade would be satisfactory. The writer, however, happened to have an "oxone" generator, and used oxygen made therein, which, of course, is nearly 100% pure gas, and differs from that made in some ways, notably from liquid air, which has been upon the market. If made from chlorate of potash and manganese dioxide, the percentage of oxygen should be nearly as high. It may, however, be that it would not be requisite to have pure oxygen, although the larger the percentage of oxygen, the less the force of the stream impinging upon the graphite would have to be for the same activity in combustion.

Laboratory of Samuel P. Sadtler & Son,
July 15, 1907.

GRAY IRON ORES OF TALLADEGA COUNTY, ALA.

The gray iron ores of Alabama occur in a belt that is confined almost entirely to Talladega County, and although this belt of ore has long been known, having been reported by Tuomey in 1858, but little attention has been paid to it as a source of iron. The only company now in active operation in this region is taking out ore at but one locality—the Mesaba or Tallaseehatchee mine, on Tallaseehatchee Creek.

Practically all the so-called gray ore is hematite, but in places the percentage of magnetite is so large that the ore is somewhat magnetic. Its name, derived from the ashy gray color which it takes on weathering, not only describes it but serves to distinguish it from the brown or red ores of the northern part of the State.

The economic importance of these gray ores is regulated by four factors, all of which should be carefully considered before extensive development work is undertaken. These are cost of mining, value of ore, cost of smelting, and opportunities for marketing products. These factors, as well as the occurrence and character of the ore, are briefly discussed by Philip S. Smith in a paper recently published by the United States Geological Survey as part of its annual volume on economic geology (Bulletin No. 315), copies of which may be obtained by applying to the Director of the Survey at Washington, D. C.

PRODUCTION OF BAUXITE AND ALUMINUM IN 1906.

The production of bauxite in the United States in 1906 amounted to 73,332 long tons, valued at $368,311. Compared with the production in 1905, 48,129 long tons, valued at $240,292, the production in 1906 has increased 27,203 tons—nearly 57 per cent.—while the average price per ton remains almost the same. Arkansas still leads in production, the other producing States being Georgia and Alabama.

The use of low-grade bauxite for the manufacture of refractory brick and the prospective new developments in the aluminum industry have stimulated interest in deposits of bauxite. In Tennessee developments have already begun on deposits at Missionary Ridge and at East Lake and Sherman Heights, suburbs of Chattanooga. Bauxite has been noted in California and also in Kentucky.

Bauxite in the form of bricks has proved to be of great value as a refractory material for lining basic open-hearth steel furnaces and lead-refining furnaces, being superior to fire brick for these uses.

As an ore of aluminum bauxite is still in great demand. The production of aluminum has increased in twenty years from 18,000 pounds to nearly 15,000,000 pounds annually, its production in 1906 having been 14,910,000 pounds. This increase in production was accompanied by a very substantial reduction in price. The application of the metal to new uses from time to time and its increased employment in old ways has caused a constant demand for it, which has not been fully supplied.

Recent plans of the Aluminum Company of America, formerly the Pittsburg Reduction Company, contemplate the erection of a model factory town, comprising 200 new houses, for the employees of its factories at Massena, N. Y., and a mill for rolling aluminum sheets at its New Kensington, Pa., plant.

Projects are under way which, if realized, will place in the field several competitors for the aluminum trade. One of these projects, it is reported, will be located on Cumberland River, about twenty-five miles from Williamsburg, Ky., where the river falls about sixty feet. The enterprise involves the construction of a dam which will provide 20,000 horsepower at any season of the year. . .

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," on the production of bauxite and aluminum in 1906, by E. F. Burchard, is now ready for distribution. The pamphlet comprises a note on aluminum salts, including alum and aluminum sulphate, with descriptions of undeveloped deposits of these salts in Nevada and New Mexico.

Much difficulty is usually found in making paint adhere firmly to galvanized iron. The United States Government has adopted specifications which appear to give satisfactory results and which call for the use of vinegar in washing the surface before painting, which washing roughens or corrodes the surface and gives the paint better adhesion.—*Eng. and Min. Jour.*

Mechanical and Engineering Section.

(Stated meeting held Thursday, April 11th, 1907.)

Direct and Indirect Methods of Electrical Purification of Water.

By Henry Leffmann.

It is about a century since the results of electrolysis began to attract attention, but the commercial exploitation of the processes was impossible until the economic production of the processes practical. So far as the purification of water is concerned, but little result was expected from electrolytic methods until the discovery of the microbic life in water and its relation to disease. The latter discovery was promptly made the basis of a rapid and brilliant, but in some respects untrustworthy development. Water analysts, and sanitarians generally, were often misled by the statements emanating from bacteriologic laboratories. Even to-day, we must receive with caution publications from such sources, especially tabulated results of experiments.

It is not necessary to review the history of the application of electrical currents to water purification, nor to describe even briefly the numerous patents that have been granted for such purposes. I propose to refer here only to some that have come under my own observation, in consequence of having been asked to make expert investigations. Some attempts have been made to remove the mineral impurities from water by taking advantage of the electrolytic powers, but most processes have been intended to kill the microbes. The ordinary inventor has proceeded upon his (generally superficial) knowledge that the disease-carrying power of water is dependent upon bacteria, and that electricity in sufficient strength is fatal to living matter.

In some of the processes the method has been the crude one of simply passing electric discharges through the water, hoping to kill the bacteria by direct shock. Thus, in one patent which was submitted to my consideration a few years ago, the inventor pro-

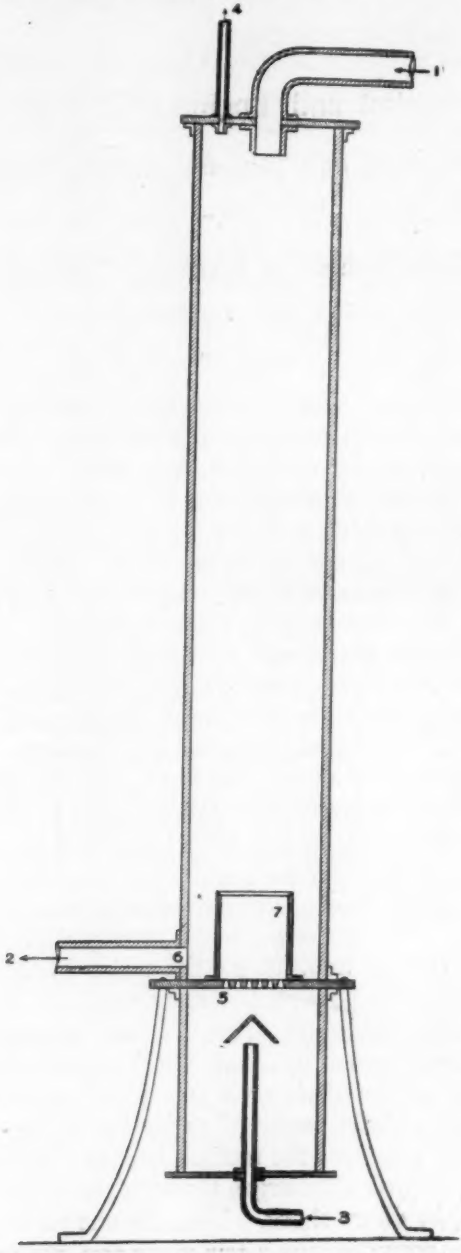


Fig. 1. Scheme of arrangement of tower for mixing ozonized air with the water.

poses to have electrodes passed into the water-main through insulated sockets and discharge a succession of sparks across the stream. The impracticability of the method, on anything but the most minute scale, seems not to have appeared to him, but what I consider much worse, the absurdity was unregarded by the patent office. It has seemed to me that there are limits beyond which the authorities of the patent office should not allow the sanction of their protection. I am well aware of the fact that many processes ridiculed by experts, have been successfully applied, but a limit of permissibility can be set without working injustice. Too many patents are granted that are inoperative and are, or should be, known to be so by the examiners who have experience in such matters.

I have seen in operation several methods of water purification by means of electrolysis. In these aluminum electrodes have been used, and more or less loss of the metal has occurred, it being converted into aluminum hydroxide. This produces its usual effect, that of combining with the organic matter and entangling the suspended substances so that the water, after treatment, can be subjected to a rapid filtration and will show material improvement in microbic content, especially if the amount of suspended matter and microbic content were previously high. On waters containing but little suspended impurity, living or dead, the purifying action is relatively low. The constant loss of the electrode is, of course, a most serious item of expense, generally overlooked in the experimental plants.

Two of the plants in which aluminum electrodes were used may be described with advantage in some detail, as some incidental features are of interest. In one, large aluminum plates two feet long and several inches wide were immersed in the water in a tall jar and the current passed through. The experimenters selected (probably with a view of more profoundly impressing inexperienced observers) very muddy water from the street gutter in front of the building in which the plant was located. The current seemed to cause the mud to collect and settle rapidly and the water became soon fairly clear, but analysis showed ammonium compounds and nitrates in abundance, and it was evident that the purification was nominal. The parties had but little money and were trying to interest a Philadelphia business man, but I could not make any but an unfavorable report.

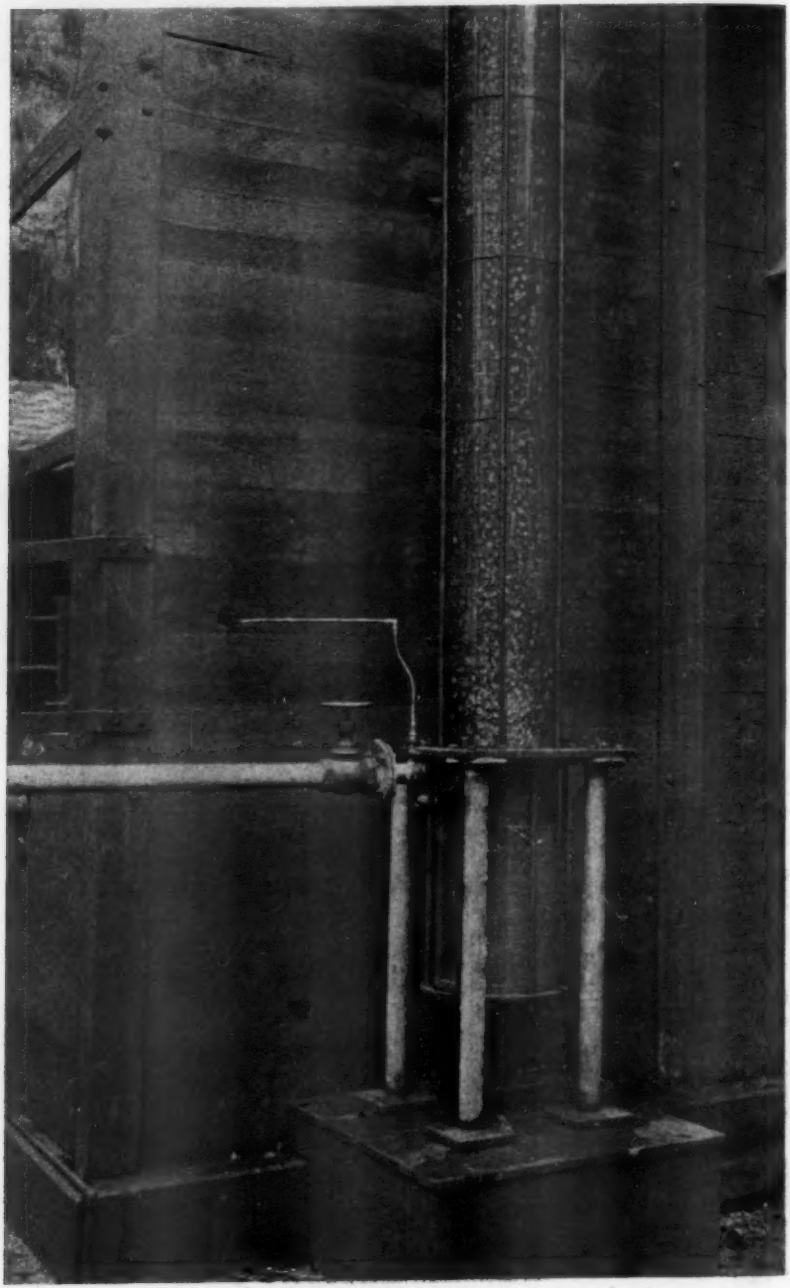


Fig. 2. View of exhibition mixing tower at Philadelphia plant.

In another case I was asked to examine a plant that was in operation near Eighth and Chestnut Streets, Philadelphia. One of the parties operating the plant claimed that the scale-forming ingredients could be removed from Schuylkill water as well as the other impurities. As this was a very broad and seemingly unwarranted claim, I was much interested in the basis for it. The promotor furnished me with a sample of water, said to be Schuylkill (city) water so treated and purified, but on taking the total solids I found the dissolved fixed matter to be just about that of the amount in the city water. It was evident that no material diminution of the dissolved solids had occurred. At the urgent request of the promoters, I visited the plant and found a very elaborate installation, mostly of closed vessels, some of which were taking the street current through ammeters and voltmeters, and from others of which a clear water could be drawn in considerable amount. The operators showed me specimens of water containing a large amount of sediment, mostly in flakes, which they claimed to be the "scale-forming ingredients." I was at first much puzzled by this sediment, as I had not been informed as to the construction of the electrifying apparatus, but when I learned that aluminum electrodes were used I recognized at once that the precipitate was aluminum hydroxide. The process was, of course, entirely unsuited to the purposes for which it was devised.

In the operation of the Anderson process of purifying water by agitation with metallic iron, attempts have been made to get more powerful action, that is, more rapid solution of the iron, by making it the positive pole of an electric system, but no practical advantage seems to have been attained. Recently, a process has been patented in which an electric current is passed from an inner to an outer pipe, the water flowing through the annulus, but I have no practical knowledge of this method.

It seems to me that the most practical benefit of the application of electricity to water purification will come from the indirect methods in which the electrical energy used to produce an active disinfecting agent, and this is then applied to the water. Of all the processes of this type, those which produce ozone seem to be most useful. The material from which ozone is obtained—air—is in unlimited supply and the addition to water cannot be re-

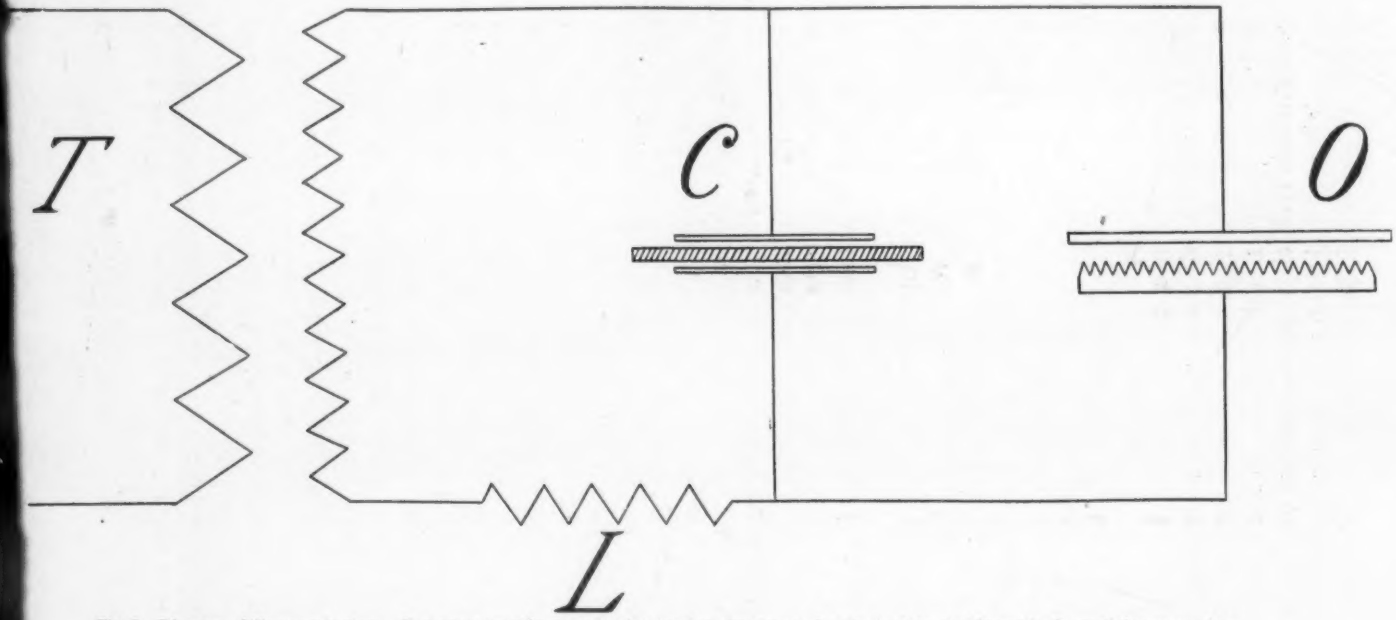


Fig. 3. Diagram of Vosmaer system. T, step-up transformer; C, high-tension condenser; L, high-tension choking coil; O, ozonizing apparatus.

Journal Franklin Institute, vol. clxiv, September, 1907

garded as being dangerous, since if present in excess it soon reverts to the condition of ordinary oxygen.

The principal problem in this method is the economic production of ozone. This modification of oxygen can be obtained by several methods of different types, but those in which electricity is employed seem to be alone applicable to the processes in question here. For the purpose, high-tension currents are most economical, and the best yield is obtained by the so-called "silent discharge." It is now known that a spark or arc discharge will produce nitrogen oxides which are corrosive. It has also been determined that the air intended for production of ozone should be dry, otherwise hydrogen dioxide will be formed. The principal mechanical difficulty encountered in producing ozone on the large scale by means of the electric discharge is to secure a suitable dialectric. Glass, porcelain, rubber and other materials have been tried but are so liable to fracture or perforation that serious interruptions of operation frequently occur. Continuity of action is very important in commercial processes, such as the purification of water, and when a large unit of the plant is out of use in order to install a new dialectric, the condition is annoying.

The inventions of Vosmaer seem to overcome the difficulty, for he avoids the use of a special dialectric, employing only the dry air which is to be ozonized. The discharge takes place from thin metal strips on which are saw-like teeth. These strips are held by insulating (porcelain) sockets, firmly in the center of metal pipes. Many of these pipes are combined in parallel, the strips being all connected with one pole and the pipes with the other. An alternating current of high potential is allowed to flow through the arrangement, almost all the current passing by silent discharge, although at times a spark passes, but as there is no permanent dialectric, no damage is done. The sparking is too seldom to produce damage or any appreciable amount of objectionable gases. The drying of the air may be done by any of the known methods; preference is given by Vosmaer to refrigeration, by means of an ordinary ice machine.

A plant capable of purifying many thousand gallons in twenty-four hours has been for some time in operation on the west bank of the Schuylkill River at the foot of Locust Street, Philadelphia. The cuts will show the general arrangements, but a brief description will aid in understanding the operation.

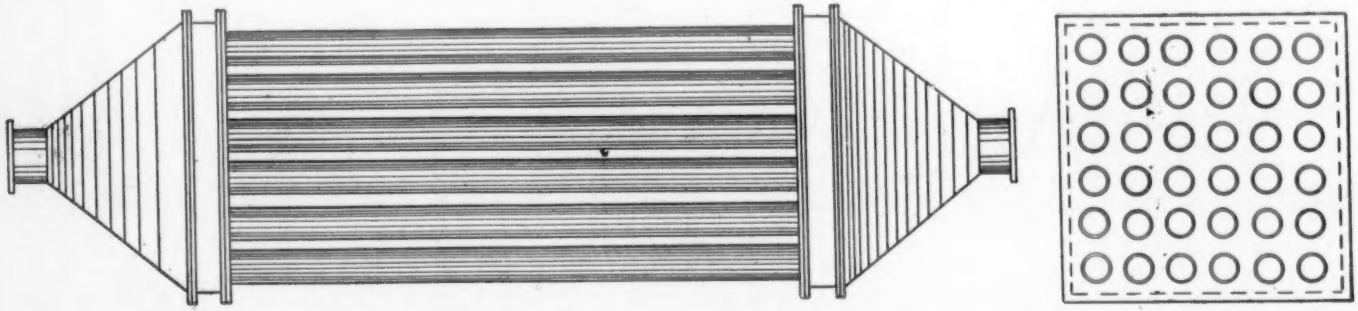


Fig. 4. Longitudinal and end-view of tubes of ozonizer.

The water is first roughly filtered. This operation is merely intended to remove the grosser suspended matter, as the ozone process proper does not accomplish this. As the main part of the operation is the destructive action of the ozone on the bacteria, it is not necessary for the preliminary filtration to be nearly so close as when the latter is the sole reliance (as in ordinary filter plants), hence the filter area in the ozone plant is relatively very much smaller, the rate of filtration being so much greater. The filtered, or, perhaps, we may call it strained water, is passed into aêrating towers. These are tall, narrow vessels, into which the water enters at the top and the ozonized air at the bottom, the latter under considerable pressure. In the experimenal plant above mentioned, an exhibition mixing tower has been installed. This is a glass tube about sixteen feet high and ten inches in diameter. In this the admixture of the ozone current with the water current is well seen. Upon the thoroughness of this mixing depends, in large part, the thoroughness of the purification. The water escapes at the foot of the mixing tower, clear and practically sterile. It sometimes contains a small amount of ozone in solution, but this is not objectionable and soon disappears, either by conversion into ordinary oxygen or by combination.

The advantages of the process may be summarized as follows:

No objectionable chemical is introduced into the water.

Large filter beds are not required.

The operation expenses are not high.

The plant occupies a limited area and the operation is simple and easily comprehended.

The plant may be enlarged by the addition of new units without disturbing the original units.

The sterilization is rapid and certain.

The plant may be placed at any convenient point.

The process seems to me to find even more valuable application to the purification of sewage than to ordinary water supply. Both of these problems are now among the most urgent questions of sanitation. The extensive use of water in our domestic life, with the increasing sources of pollution, give importance to every method of purification, and processes that seem to be founded on scientific principles and seem capable of practical operation on a large scale, and to involve low operative cost, limited land area

Journal Franklin Institute, vol. clxiv, September, 1907

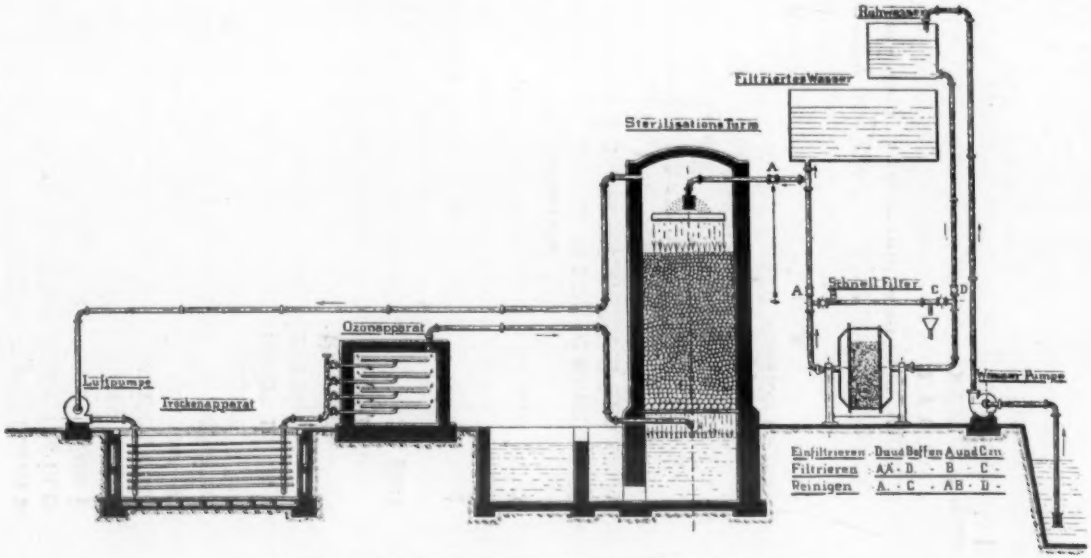


Fig. 5 General view of plant for purification of water by ozone

and freedom from dangerous chemicals deserve careful investigation.

Many tests of the bacteriocidal efficiency of the plant have been made. Some made by myself showed that the water as discharged from the ozonizer is practically sterile. The following more elaborate tests, extending over many weeks, were made by Dr. Rivàs, official bacteriologist of the City of Philadelphia, supplanted by independent tests by Drs. Jackson and Hale, city bacteriologists of Greater New York.

DR. RIVAS.

Date	Sample	Bacteria Before Ozonization (includ'g disease germs)	Bacteria After Ozonization (no disease germs)	Organic Matter in Solution Before	Organic Matter in Solution After
May 15, 1905	1	720,000	16	15.21	7.7
May 15, 1905	2	253,000	37	13.33	8.89
May 18, 1905	1	500,000	55	11.96	7.51
May 18, 1905	2	500,000	38	19.92	7.11
May 19, 1905	1	700,000	5	10.07	6.52
May 19, 1905	2	700,000	0	12.64	6.72
Average		562,100	25		

DRS. JACKSON AND HALE.

				B. Coli after Ozone.
May 19, 1905	1	665,000	15	0
May 19, 1905	2	648,000	13	0

More recent tests confirm the foregoing.

The following figures show a series of tests with statement of operative cost:

Date	Quality of Water gals. per hr.	Bacteria Before Ozoniza'n.	Bacteria After Ozoniza'n.	Electrical Expendi'e K.W.hr.	Rate per million gals. in K.W.hrs.
Dec. 14, 1905	31,200	1,500	2	6.1	196
Dec. 14, 1905	30,000	2,000	2	6.0	200
Dec. 14, 1905	30,300	2,600	4	6.0	198
Dec. 15, 1905	30,900	2,100	2	5.5	178
Dec. 15, 1905	31,300	1,000	2	5.9	188
Dec. 15, 1905	30,000	1,300	5	5.8	193
Dec. 18, 1905	29,900	5,600	4	5.6	172
Dec. 18, 1905	31,000	1,000	5	5.6	181
Dec. 18, 1905	28,500	1,200	1	5.5	193
Dec. 19, 1905	30,000	750	2	5.5	183
Dec. 19, 1905	29,000	550	4	5.6	193
Dec. 19, 1905	27,000	9,900	19	5.6	208

Dec. 19, 1905	28,000	6,000	3	5.5	197
Dec. 19, 1905	30,000	3,700	4	5.5	183
Dec. 20, 1905	29,000	2,900	1	5.5	190
Dec. 20, 1905	28,400	4,100	2	5.6	197
Dec. 20, 1905	28,400	7,100	5	5.6	197
Dec. 20, 1905	28,000	5,700	5	5.8	207
Dec. 21, 1905	29,000	8,600	13	5.5	190
Dec. 21, 1905	28,000	8,700	11	5.5	197
Dec. 21, 1905	27,000	16,400	15	5.8	215
Dec. 21, 1905	26,000	2,700	6	5.5	212

FOREST SERVICE TIMBER TESTS.

Extensive tests to determine the strength of the commercial timbers of the United States are being made by the Forest Service. Such information is of great value to architects and engineers in that it enables them to use more economically the products of the forest. The tests are made on large beams. The material is generally tested while green, since timber is weakest in the green condition. The strength of a beam is indicated by the greatest fibre stress developed during the test. Technically speaking, this breaking strength is termed the modulus of rupture. By using it the load that any beam will carry can be calculated. In the table below the first column gives the green breaking strength of our principal commercial timbers. The second column gives the greatest load that a timber five inches wide and twelve inches high, with fifteen feet between the supports, would hold if the load were concentrated midway between the supports.

Species.	Breaking strength in bending. lbs. per sq. in.	Breaking load concentrated midway between supports, for a beam 5 x 12 in. x 15 ft. lbs.
Longleaf pine	7,772	20,700
Douglas fir	7,500	20,000
Western hemlock	5,783	15,400
Loblolly pine	5,580	14,900
Tamarack	4,562	12,300
Norway pine	3,975	10,600

If instead of being concentrated at one point the load were uniformly distributed over the entire length of the beam the beam would hold twice as much. In order to insure safety, in practice beams are seldom allowed to carry more than one-sixth their breaking loads.

Mining and Metallurgical Section.

(Stated Meeting held Thursday, January 26th, 1906.)

The Schuyler Mine.

By J. H. Granbery,

Associate Member Am. So. C. E., Member of the Institute.

(*Concluded from p. 28*)

The geological formation is shown in Fig. 1. The illustration shows the face exposed by quarrying for sandstone. All the mining that was carried on for the early part of the operation was done by shaft working; and it is only through the quarrying operations referred to that so much of the bedding plane of the ore body is exposed to view. In the figure is shown a blacksmith shop, and a temporary power plant, used for furnishing the current to operate electric drills. The quarry floor "C" is the top of a bed of red sandstone and shale; the gray sandstone lies in two layers above it. The lower extends from "C" to the lower edge of the seam "B," and the upper extends from the upper edge of "B" to the shale and brecciated trap at "A." The two layers are each, at this exposure, about eleven feet thick; the seam "B" is a shaly slate that runs from six to nine inches thick, and carries about six per cent. copper.

At the opening "D," where it cuts through the two layers of sandstone and the seam "B," the presence of calcite is shown by the white streak where the roof of shale and trap is broken out. The shale and trap themselves, at this point, carry considerable copper. The openings referred to are indicated by the letters "D" and "A" on the accompanying map, Fig. 2. Here the tortuous character of the workings is clearly shown.

Fig. 1. Geological formation, exposed in the open quarry. The view is taken from the southern end.

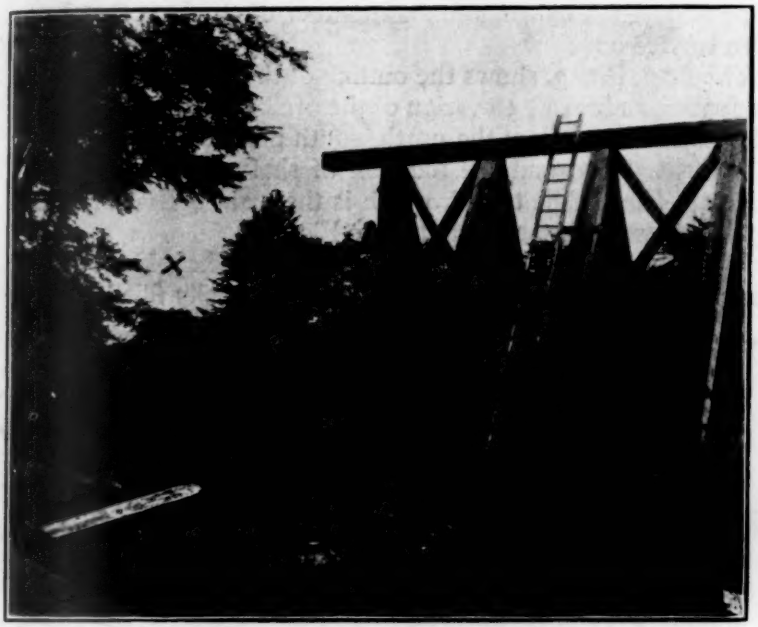


Fig. 4. The Victoria shaft.

Drift "D"

Drift "A"

Fig. 5. The quarry, view taken from the northern end.

The process of "following the ore" was apparently profitable, if we may judge by the size and number of stopings that have been carried on.

The map, Fig. 3, shows the outline of the outcrop and gives an approximate scale elevation of the ore body as it is exposed. The dotted lines show the north, south and middle drain tunnels respectively, and the location of shafts is shown by the circles. The middle tunnel, which is the main outlet for drainage, is shown to better advantage in Fig. 2.

With the exception of the "Victoria" and Shaft No. 1, all of the old shafts were caved or had become partially filled up pre-

Fig. 6. The reduction plant, built in 1900-01.

vious to 1899. The other open shafts were reopened by the operators who took over the property at that time; they drove no new shafts.

In Fig. 4 is shown an old ladder, found below the water line, in the Victoria shaft; this was made of oak and had been submerged for thirty-five years; it was very heavy, due to the water it had absorbed, but strong and still capable of hard usage. At the foot of the ladder is shown a section of piping of a form that is unusual at this day; this is the pump valve of the old Cornish pump. The flanges shown were used for attaching the valves. The old pipe was joined, not by flanges or screwed connections as in present practice, but by a method

somewhat similar to the bell and spigot connections used for water mains. The joints were not leaded, but were packed with rope and tar, and then a sleeve was driven on to hold the pipes and the packing in place. Fragments of the old Cornish pump rod may be seen at the extreme left of the figure, and in the open space marked by the cross are still to be seen the foundations of the first steam engine in America.

The stamp mill used by the Brisk company was just off the limits of the picture; and in 1900, when this shaft was retimbered under the author's direction, an old stone wall was unearthed that had, to all appearances, formed the outer wall of the old engine house.

Fig. 5 shows the general appearance of the quarry face and floor after some months of operation. The entrances into drifts are shown, and marked to identify them; the quarry floor is buried under about ten feet of ore—taken out in the interval between making photographs of Fig. 1 and Fig. 5. The South quarry is seen in the distance, and to the left of the illustration is the steel framework for the crushing and milling plant. The plant itself is shown in a more general way in Fig. 6, where the frame for this building is shown partly erected.

At the left of Fig. 6, directly below the small "timekeeper's house," is seen the lock-cribbed shaft for cleaning out the main drain tunnel. This is marked upon the map, Fig. 2, in the lower corner. The stone building in the foreground is the power house, that to the right, back of the well drilling machinery, is the deposition building, where the metallic product was designed to be produced. Between this and the furnace building directly above it were the leaching tanks, four in number, designed to handle 125 tons of ore per day. The brick stack has a column 100 feet high, and the top of its foundation is sixty-five feet above the meadow.

In drilling the well indicated by the location of the machinery for that purpose, ore was found at considerable depth, and the suggestion has been advanced that there may be a secondary enrichment of the country rock at greater depth. No other borings were made to confirm this hypothesis, however, and it is doubtful, even if such confirmation were forthcoming, whether the material could be obtained at a profit under the

Fig. 7. The dump, where quarry waste was disposed of.

circumstances. The well is 343 feet deep, with an eight-inch casing at the top.

Fig. 7 shows an old waste dump, containing something like 5000 cubic yards of mixed gob, ore and dirt. Some of the most perfect examples of malachite were found in the process of excavating parts of this dump. The garden shown in the immediate foreground is the site of the deposition building shown in Fig. 6. This photograph was made during the period of construction in 1900-1901, as were those reproduced in other portions of this article.

ELECTROLYTIC CORROSION OF IRON AND STEEL IN CONCRETE.

In a paper read at the two hundred and fourteenth meeting of the American Institute of Electrical Engineers at New York, March 1, 1907, A. A. Knudson presented the results of research he had carried on for several years to ascertain whether concrete will afford iron and steel the same protection from stray currents of electricity as it gives against ordinary corrosion or rust. In addition to the laboratory experiments detailed the author of the paper refers to two practical cases of the recognition of electrolytic action in important steel structures. The first of these is the bridge over the Gowanus Canal, South Brooklyn, N. Y., at Hamilton avenue. The Bridge Commissioner, in his report for the year ending June 30, 1906, said that the foundation walls developed some rather serious cracks on both sides of the canal, with a movement of the walls toward the center of the canal.

ELECTROLYTIC ACTION ON BRIDGE STEEL.

To ascertain the electrical conditions, Mr. Knudson made some tests at the above mentioned bridge, the results of which are thus stated:

The voltmeter readings show the steel structure to be positive to the canal, positive to water mains in the street, and positive to the trolley rails on the bridge, ranging from 0.5 to 1.5 volts. These readings were taken when the car traffic was light. Some of the cracks on the concrete had been plastered over, but others were quite visible. The tests indicate that the trolley tracks on the bridge are in connection with the steel structure. Tests were also made on another bridge of the same construction a little further north over the same canal, at Ninth street. The readings here were exactly the reverse to those found at the Hamilon avenue bridge, the structure being negative to canal, water mains and tracks. There were no visible cracks in the concrete of either foundation. Although the cracks in the concrete of the Hamilton avenue bridge are attributed to other causes in the commissioner's report, we believe these tests and observations point strongly to electrolytic action from trolley currents as being the

true cause. This seems to us the more reasonable cause of these cracks, in view of the results of our laboratory experiments. Ordinary care would suggest that costly structures of this kind should be periodically inspected for evidence of electrolytic action upon the interior steel work especially if located contiguous to water, or in the vicinity of electric railroads or railroad power stations, as in the case just cited. Furthermore, this question should be carefully considered when such structures are planned, tests made at locations of proposed bridges or other structures, to ascertain the electrical conditions and the possibilities of injury due to electrolysis from stray currents.

PROTECTION AGAINST CORROSION IN BUILDINGS.

The paper cites the "Times" Building, New York, as a conspicuous instance of care to prevent destructive action of electrical currents. One precaution taken there was the thorough waterproofing and draining of retaining walls, this being carried under the floor of the press room occupying the subbasement. As a further safeguard all the steel members up to the street level were encased in Portland cement mortar to the minimum thickness of ¾ inch. This is effectual protection against rust deterioration, and is believed to be also against electrolytic disintegration. As perfect insulation as possible is also provided, there being sufficient grounding to relieve any electrical tension which may exist in any part of the steel frame by drawing off the current at points where electrolytic action cannot be set up.

Accompanying the paper are views of two water meters, the under sides of which were practically destroyed by electrolysis while in service in the cellars of dwellings in a city distant from New York. These cases, which are by no means isolated, illustrate how trolley line currents will follow a service pipe for a considerable distance from the tracks, enter a building, and find an outlet to ground on the damp soil of a cellar. This furnishes an opportunity for current to pass into the iron foundations of large buildings where such service pipes, either water or gas are connected, as they usually are, to the framework of such structures. Mr. Knudson has discovered many similar cases of current straying into buildings in different cities in this country. Three meters were found destroyed in this way in different sections of the city from which they were taken. They were from one to two miles apart. The distance from the tracks of one was 300 feet, and of another 675 feet. All the meters were on side streets at right angles to the car tracks.

CONCLUSIONS AND REMEDIES.

The conclusions reached by the paper and the remedies suggested are thus stated:

Coatings of various kinds of paint or varnishes will be of little use as an insulation, for it must be borne in mind that not only a moisture resistant is required, but an insulation that will resist continual moisture, and also that will stand the pressure of great weight. From laboratory experiments as well as observations in practice, we draw the following conclusions:

1. Steel structures are well preserved from ordinary corrosion by concrete if placed either in salt or fresh water This, however, has long been known.

2. If but a small fraction of an ampere of electricity passes from an interior metallic column or structure into concrete or masonry as usually made, there will be corrosion of the metal and disintegration to the concrete masonry.

3. Structures of steel in concrete that are subject to sea water are in more danger from electrolytic action than those in fresh water, by reason of the lower resistance of concrete in the sea water as shown by the laboratory experiments.

4. In no sense can concrete be considered an insulator, and it is from all appearances just as good an electrolyte as any of the soils found in the earth.

"It is to be expected," says Mr., Knudson, "that so long as the single trolley with its grounded return is in general use, just so long may we look for electrolytic action in some form upon various underground structures; and reinforced concrete is no exception to the rule. It is not at all surprising that such currents are busy at steel work of bridge anchorages. Whether inclosed in concrete or masonry, these materials are no protection from the straying railroad current when the conditions are favorable for electrolytic action. In view, therefore, of the items here presented and of the enormous use to which concrete and hydraulic cements are now put, it would seem that this question should receive due consideration by those who have to do with planning and constructing important public works and buildings, as well as those who are entrusted with the care and safety of such structures."—*Iron Age.*

THE AMENDED FREE ALCOHOL LAW.

In the last week of the recent session of Congress a bill was passed amending the free alcohol law which went into force January 1, with a view to decreasing the cost of producing, denaturing and transporting spirits intended for industrial purposes. It is the opinion of those most familiar with the subject that the passage of this amendatory measure will within a short time reduce the cost of denatured alcohol to the consumer by at least five or six cents per gallon. This prospect, considered in connection with the latest quotation on denatured alcohol of 29 cents per gallon, f.o.b. Peoria, indicates that the prediction made just before the enactment of the original law that the price would be down to 25 cents per gallon within a year will be more than verified. The amendatory law does not take effect until September 1, but in the meantime regulations for its enforcement will have been promulgated and thoroughly digested by producers and dealers, so that it is fair to assume that the effect of the changes will be felt in all parts of the country before the end of the current year. The new statute provides as follows:

TEXT OF THE NEW LAW.

Be it enacted, &c., That notwithstanding anything contained in the act

entitled "An act for the withdrawal from bond, tax free, of domestic alcohol when rendered unfit for beverage or liquid medicinal uses by mixture with suitable denaturing materials," approved June 7, 1906, domestic alcohol when suitably denatured may be withdrawn from bond without the payment of internal revenue tax and used in the manufacture of ether and chloroform and other definite chemical substances that do not appear in the finished product as alcohol; provided, that rum of not less that 150 degrees proof may be withdrawn for denaturation only, in accordance with the provisions of said act of June 7, 1906, and in accordance with the provisions of this act.

Sec. 2. That the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may authorize the establishment of central denaturing bonded warehouses, other than those at distilleries, to which alcohol of the required proof may be transferred from distilleries or distillery bonded warehouses without the payment of internal revenue tax, and in which such alcohol may be stored and denatured. The establishment, operation and custody of such warehouses shall be under such regulation and upon the execution of such bonds as the Comimssioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe.

Sec. 3. That alcohol of the required proof may be drawn off, for denaturation only, from receiving cisterns in the cistern room of any distillery for transfer by pipes direct to any denaturing bonded warehouse on the distillery premises or to closed metal storage tanks situated in the distillery bonded warehouse or from such storage tanks to any denaturing bonded warehouse on the distillery premises, and denatured alcohol may also be transported from the denaturing bonded warehouse, in such manner and by means of such packages, tanks or tank cars, and on the execution of such bonds, and under such regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe. And further, alcohol to be denatured may be withdrawn without the payment of internal revenue tax from the distillery bonded warehouse for shipment to central denaturing plants in such packages, tanks or tank cars, under such regulations and on the execution of such bonds as may be prescribed by the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury.

Sec. 4. That at all distilleries producing alcohol from any substance whatever, for denaturation only, and having a daily spirit-producing capacity of not exceeding 100 proof gallons, the use of cisterns or tanks of such size and construction as may be deemed expedient may be permitted in lieu of distillery bonded warehouses, and the production, storage, the manner and process of denaturing of such alcohol, and the operation of such distilleries shall be upon the execution of such bonds and under such regulations as the Commisiosner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe, and such distilleries may by such regulations be exempted from such provisions of the existing laws relating to distilleries as may be deemed expedient by said officials.

Sec. 5. That the provisions of this act shall take effect on September 1, 1907.

THE EFFECT OF THE CHANGE.

Section 1 of the law is of much importance. The Commissioner of Internal Revenue having held that no "liquid medicinal preparation" could be manufactured with the use of denatured alcohol under the original law, producers of smokeless powder, lacquers, enamels, &c., in which ether is used as a solvent, found themselves unable to secure the benefits of the free alcohol policy. The artificial silk industry, for the establishment of which in the United States a million-dollar corporation had been organized, was also denied the use of denatured alcohol, because of the fact that it is employed therein in the manufacture of ether, which, even when used for mechanical purposes, was held by the Internal Revenue Bureau to be barred as a "liquid medicinal preparation."

The provisions of Section 2 are relied upon to develop the industrial use of alcohol to a degree not heretofore contemplated. It will permit any manufacturer to establish a denaturing bonded warehouse and to transport thereto pure grain alcohol for his own use, thus saving the freight on the denaturing materials and the charge made by the distiller for the denaturing process. A manufacturer of brass goods, for example, may set apart one or two rooms in his establishment, transport thereto pure alcohol, denature it and use it in the manufacture of lacquers. Compared with the present cost of tax-paid grain spirits, fusel oil and other solvents for this purpose, it is estimated that the saving in the cost of lacquers will be not less than 50 per cent. and probably more. Hardware manufacturers, who use enormous quantities of enamels, metal varnishes, paints, &c., will enjoy the benefits of the amended law in a similar manner.

The general consumer of denatured alcohol will derive the greatest benefit from the provisions of Section 3. Under the original alcohol law the pure spirit was required to be drawn off into barrels before being removed to the denaturing warehouse, a tedious and expensive process, which is obviated by Section 3, which permits the spirit to be piped from one department to another, thereby saving not less than one-half cent a gallon, according to the estimates of the experienced distillers. The largest saving effected under this section, however, will grow out of the use of tank cars for transporting both pure grain spirits in bond and denatured alcohol without restriction. On this point the Ways and Means Committee, after careful investigation, embodied the following statement in their report upon the bill just enacted:

With reference to the economy of the tank car system, your committee has been advised that the railroads make no charge for handling empty tank cars back to the point of shipment. Their practice is to charge the same rate of freight as if the article was carried in barrels, and to make an allowance for mileage both coming and going. The charge for the freight and the payment of the mileage are two distinct transactions. When the article is shipped in barrels the weight of the barrels is included in the freight charges. When shipped in tank cars the weight of the tank is not included. Where empty barrels are returned to the point of shipment the rate of freight is in excess of the rate charged for the weight of such barrels when shipped to consumer, filled. It may, therefore, be safely stated that

alcohol, shipped in tank cars (since the barrels add at least three cents per gallon to the cost) will reduce the cost to the consumer at least 4 cents per gallon.

ESTABLISHMENT OF FARM DISTILLERIES.

Section 4 of the bill was enacted to permit the production of denatured alcohol on a small scale under conditions similar to those that have resulted in the establishment of nearly 8000 so-called farm distilleries in Germany. This feature of the bill is of interest from several different standpoints. The competition of the farmer in the manufacture of denatured alcohol will undoubtedly reduce its cost. The demand for small stills will build up an industry engaged in their production that will consume considerable quantities of metal. Perhaps the most important development will be the increased use of internal combustion engines and various types of small power agricultural machinery.

The Commissioner of Internal Revenue will immediately begin the preparation of an elaborate series of regulations for the enforcement of the amended law. This is a difficult and laborious task, as it will involve many changes in the internal revenue practice, even under the original alcohol law. It is expected that the new regulations will be promulgated about July 1, in order that producers, dealers and consumers may have at least two months to become thoroughly familiar therewith before the amendatory statutes go into force.—*Iron Age.*

Book Notices

Jahrbuch für das Eisenhüttenwesen: (Ergänzung zu "Stahl und Eisen"). Ein Bericht über die Fortschritte auf allen Gebieten des Eisenhüttenwesens im Jahre, 1903. Im Auftrage des Vereins deutscher Eisenhüttenleute bearbeitet von Otto Vogel. 4ter Jahrgang. 464 pages, illustrations, 8vo. Düsseldorf, A. Bagel, 1906. Price, 10 marks.

This work contains a complete review of the iron industry during the year. We find an extensive bibliography covering all the branches of the iron trade, including statistics and a review of the patent literature.

There are articles on fuels and firing, on slags and ores, and the various kinds of iron; there is much information on the working of the metal and its properties. Some space is given to alloys and mixtures of iron and the work closes with a series of articles on the testing and examination of materials.

The index, authors and subjects in two parts, is very full and accurate.

Proceedings of the Chemical, Metallurgical and Mining Society of South Africa, with appendix. May, 1902 to June, 1903. Vol. 3. 483 pages, illustrations, plates, 8vo. Johannesburg, Transvaal, published by the Society. On sale at the office of the Engineering and Mining Journal in New York.

A great amount of work has been done during the year by this young society. We find a complete record of all the papers read and a full report

of the discussion of each. The addresses cover every branch of mining and metallurgy and go quite extensively into chemistry. The book closes with a department of notices and abstracts compiled from the world's periodicals.

The mining engineer will find the volume interesting as an indication of progress in England's youngest colony.

Cyclopedia of Applied Electricity: A practical guide for electricians, mechanics, engineers, students, telegraph and telephone operators, and all others interested in electricity. Prepared by a corps of experts, electrical engineers and designers. Illustrated with over two thousand engravings. 5 vols., 4to. Chicago, American School of Correspondence at Armour Institute of Technology, 1905.

This work is made up of a series of articles written by well-known experts and covering the entire field of electricity. Volume I contains the elements of electricity, a chapter on the electric current, articles on measurements and wiring and the telegraph. Volume II is devoted to dynamos, motors and storage batteries. Volume III contains lengthy articles on electric lighting, railways and power stations. Volume IV, alternate currents and power transmission. Volume V is devoted entirely to the telephone. The writers and collaborators number seventeen, and the authorities consulted twenty-seven. The work will appeal chiefly to the artisan who is devoting his spare time to the study of the practical side of electricity.

L'Industrie Oléicole (Fabrication de l'Huile d'Olive) par J. Dugast. 176 pages, illustrations, 12mo.

Préparation Mécanique des Minerais. Resumé pratique par F. Rigaud. 171 pages, illustrations, 12mo.

Les Petits Métaux. Titane, Tungstène, Molybdène par a Truchot, 189 pages, 12mo.

Construction des Induits a Courant Continu. Partie Mecanique par E. J. Brunswick et M. Aliamet, 173 pages, illustrations, 12mo.

Construction des Induits a Courant Continu. Manuel pratique de bobinier par E. J. Brunswick et M. Aliamet. 153 pages, illustrations, 12mo.

Rivetage par M. Fricker. 168 pages, illustrations, 12mo., Paris, Gauthier-Nillars, n. d.

The above volumes are the latest additions to the well-known series Encyclopédie Scientifique des Aide—Mémoire issued under the editorial direction of M. Léauté. The books are uniform with previous issues and form valuable monographs on the subjects to which they relate. The price per volume is two francs, 50c., in paper, and three francs in cloth. R.

La Ionizzazione e La Convezione Elettrica Nei Gas. By Lavoro Amadiozzi. 368 pages, illustrations, 8vo. Bologna, Zanichelli, n. d. (Attualita Scientifiche, No. 9.)

In a letter preserved in the British Museum, Robert Bowning says: "I never pretended to offer such literature as should be a substitute for a

cigar or game at dominoes to an idle man." There are some scientific books which lead one to think that the authors were afraid of being found guilty of having written an interesting volume. The author of the above book is not fearful of this aspersion, in fact in his preface he acknowledges that he desires his book to be "plain and elementary." This commendable program is well carried out. The book is up to date. It treats in a lucid manner of the kathode, the canal and the X Rays. The treatment of the complicated phenomena which manifest themselves when a current is sent through rarefied gases seems to be admirable. The matter of the ionization of gases comes in for a full share of treatment. The Zeeman Effer and the Doppler effect in anode rays are also discussed.

It is pleasant to note that the workers of the United States and of Canada are frequently quoted,—Rutherford, McClung, McClelland and Zeleny, though how would it be possible to write a book on this subject and not mention them? The author refers modestly to his own work on the electric spark.

The general arrangement of the book is excellent. Each section has a title in heavy type at its beginning. The figures are clear and do not suffer from too much detail. The printer has done his part well. A bibliography of 154 numbers is a valuable addition.

Just a few words of criticism. A little more care might have been exercised in the spelling of proper names. McClung and McClelland appear as MacClung and MacClelland. C. Barus loses his identity as E. Barus. Phil. Trans becomes at the foot of page 360 Phis. Trans. These are but minor blemishes that would not be noticed in a less excellent book, but the omission of a comprehensive index is a defect that makes the book far less usable. Let us hope the second edition will have a worthy index.

The author is to be congratulated on having produced an excellent book upon one of the living themes of physics. G. F. S.

The Steam Engine and Other Heat-Motors, by W. H. P. Creighton, U. S. N. (Retired). First edition, first thousand. 499 pages, illustrations, 8vo. New York, John Wiley & Sons, 1907. Price in cloth, $5.00.

This very excellent work treats the elementary principles of the steam engine and other heat motors and the various forms of energy in a clear, terse and comprehensive way, that will doubtless interest that advanced class of students for whom it is intended. The work itself is a valuable addition to extant literature upon this subject and should be cordially welcomed by all those interested in this field of investigation and study.

C. E. R.

Hygromedry, by Henry Emerson Wetherill, M. D. 4th ed., rev. and enl. 82 pages, illustrations, oblong, 32mo. Philadelphia, published and illustrated by the author, 1906. Cloth, price, $2.50.

Dr. Wetherill has had considerable experience as a medical practitioner in private life and a surgeon in the army. In connection with his various

medical duties he has been constantly devising new instruments to assist the physician in his work.

In the book before us he describes in detail what is perhaps his most important invention: The Hygromed, an instrument for the measurement of the moisture of the body. In the supplementary pages we find brief descriptions of Dr. Wetherill's other devices. R.

Augosto Righi. La Moderna Teoria dei Fenomeni Fisici. (Radioattivita, Ioni, Elettroni) Ed. 3, considerably enlarged. 290 pages, illustrations. 8vo. Bologna, Ditta Nicola Zanichelli, 1907. Price, paper, 5 lire.

We have in this book a complete review in simple, lucid style of the electron theory, its many applications in the various branches of physics and the readjustment of the modern ideas to conform to this theory.

The whole is concluded with a bibliography containing one hundred and ninety-nine references.

The book is issued in good style as No. 3 of the series "Attualita Scientifiche."

Concrete Factories. An illustrated review of the principles of construction of reinforced concrete buildings, including reports of the Sub-Committee on Tests, the United States Geological Survey and the French rules on reinforced concrete. Compiled by Robert W. Lesley. 152 pages, illustrations, 8vo. New York, published for the Cement Age by Bruce & Banning, n. d. Cloth, price, $1.00.

There is already a number of books on reinforced concrete, but the present work deals more especially with the subject of factory buildings. The compiler is editor of the Cement Age, and is thoroughly familiar with the needs of the modern architect.

The work contains a review of the principles underlying reinforced concrete construction in clear and concise language.

There are reports of tests of various government committees and boards and a complete text of the French rules for the design of structures in reinforced concrete.

Nearly all the cement experts have contributed articles, making the book extremely useful. The illustrations are appropriate and interesting. We would suggest that a complete index be included in the next edition, this would make the book still more useful. R.

Notes on Mechanical Drawing, prepared for the use of students in mechanical drawing at the University of Pennsylvania, by Horace P. Fry, B.S. in E.E. 55 pages, illustrations, 8vo. Philadelphia, printed for the University, 1905.

This work is intended as a hand-book to be used by the students of the University in connection with their class work. It is not an exhaustive treatise on the subject, but a reference book containing hints, tables and other information in use among American draughtsmen. There are already many treatises and hand-books on drawing, but this latest arrival will undoubtedly be well received by engineering students. R.

The Steel Square as a Calculating Machine, being simple directions for using the common steel square for the solution of complicated calculations that occur in the everyday work of carpenters, builders, lumber dealers, plumbers, gas fitters, engineers, electricians, tinsmiths, blacksmiths, masons, stone cutters, etc., with numerous illustrations, by Albert Farr. 81 pages, illustrations, 12mo. New York, Industrial Publication Company, 1906. Price, 50 cents.

This latest work on the slide rule is intended for the mechanic, and is written in simple language without mechanical terms. It describes the use of the square for the solution of the many problems which present themselves to carpenters, machinists and others in the course of their work. R.

Untechnical Addresses on Technical Subjects, by James Douglas, LL. D. 84 pages, 12mo. New York, John Wiley & Sons, 1904. Price, $1.00.

Three addresses are included in this book, the first on "The Characteristics and Conditions of the Technical Progress of the Nineteenth Century." the second on "The Development of American Mining and Metallurgy and the Equipment of a Training School;" the third on "Wastes in Mining and Metallurgy."

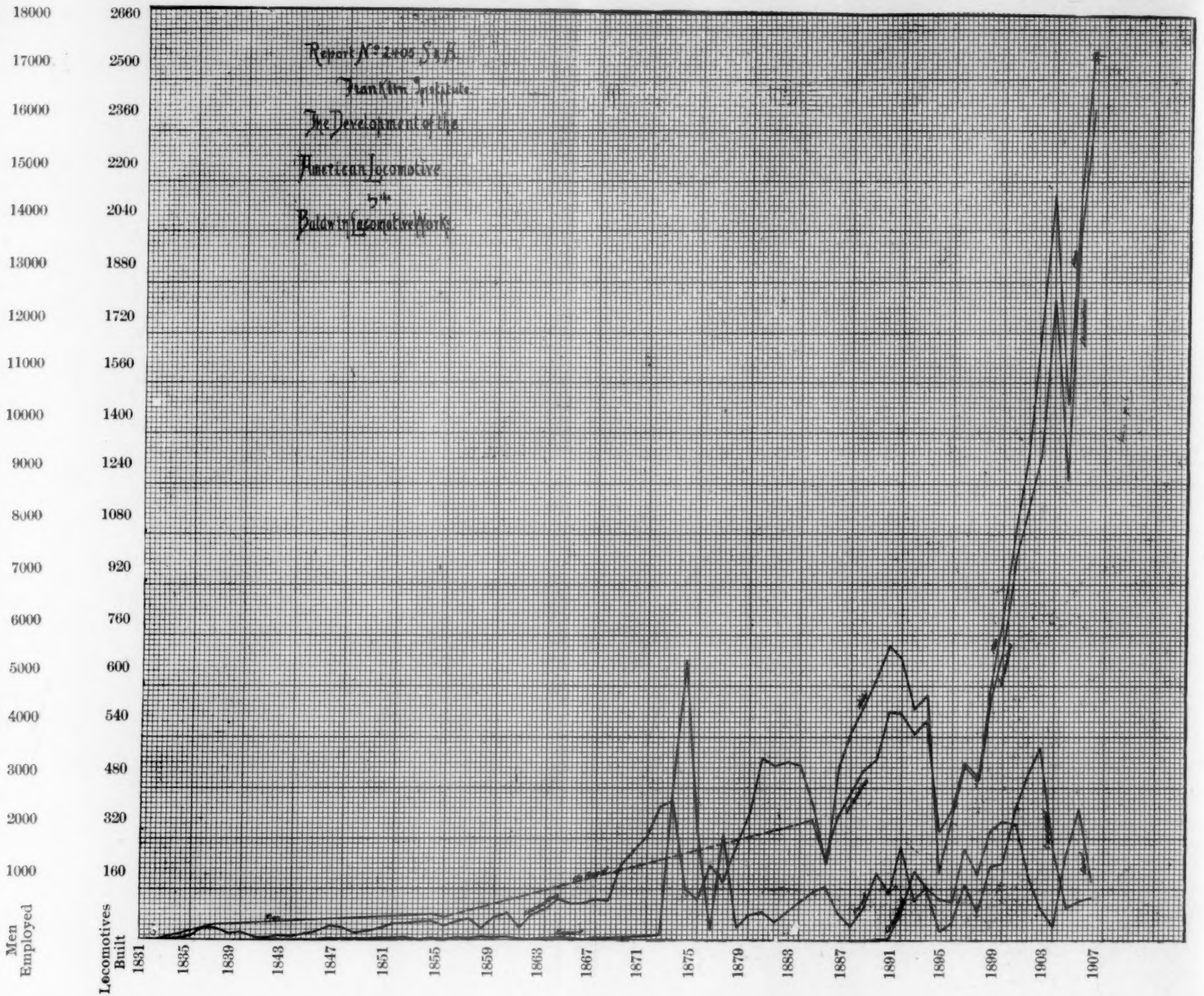
The addresses are popular in character and make interesting reading. R.

Fortschritte in der Anwendung der Röntgenstrahlen von Dip-Ing. Dr. phil. Josef Rosenthal, München. 31 pages, illustrations, 8vo. München, J. F. Lehmann's Verlag, 1906. Paper, price, 1.20 mark.

This pamphlet is a reprint of an address delivered by Dr. Rosenthal before the Society of Natural History of Munich. It is a resumé of the ten years' work with the Xrays put in plain words to meet the needs of the average reader. R.

Aide-mémoire de Photographic pour 1903 publié sous les auspices de la Société Photographique de Toulouse par C. Fabre. 28me année, troisieme serie, tome VIII. 299 pages, illustrations, 24mo. Paris, Gauthier-Villars, n. d., paper, price, 1.75 franc.

This annual contains a review of progress in the various branches of photography. The contents include a directory of the photographic societies of the world, a list of patents granted in France during the year relating to photography, many exposure tables, formulæ, a bibliography and much other matter of value and interest to the photographic worker. R.


Report No 2405 S.A.
Franklin Institute
The Development of the
American Locomotive
by the
Baldwin Locomotive Works
Men Employed
Locomotives Built
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
2660
2500
2360
2200
2040
1880
1720
1560
1400
1240
1080
920
760
600
540
480
320
160
1831
1835
1839
1843
1847
1851
1855
1859
1863
1867
1871
1875
1879
1883
1887
1891
1895
1899
1903
1907